THE

AËRONAUTICAL JOURNAL.

(FOUNDED 1897 in succession to the ANNUAL REPORTS).

THE ORGAN OF THE ROYAL AËRONAUTICAL SOCIETY.

Published Monthly at the Offices of the Society, at 7, Albemarle Street, Piccadilly, London, W.1.
Telephone: "Gerrard 7373." Telegraphic Address: "Didaskalos, Piccy, London."
Subscriptions per annum, post free, £1 10s.; single numbers, 2s. 9d.

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All communications should be addressed to the Editor.

No. 101. MAY, 1919. VOL. XXIII.

Notices of the Royal Aëronautical Society.

The Stationery Office.

The illustrations to Captain Goodman Crouch's paper on the "Rigging of Aeroplanes," in the last number of the JOURNAL, were published by the kind permission of H.M. Stationery Office. We take this opportunity of acknowledging the ready and courteous assent by the office to our request for this permission.

New Members.

Member.—W. E. Nixon.
Student.—A. L. Wykes.
Associate Member.—T. C. Thrupp.
Foreign Members.—N. B. Love, N. J. Warneford.

The "Journal."

A suggestion has been made to the editorial department that it would be desirable in the interests of all concerned to publish in the JOURNAL the reports of the lectures before the Society immediately after delivery. This, it may be pointed out, is quite an impossible ideal. All printed matter in this JOURNAL must, as far as possible, be complete in itself and letter perfect. The precautions necessary to secure these results involve a certain measure of unavoidable delay. Improvements and developments in the JOURNAL will follow shortly. Our readers need not be reminded that the alteration from quarterly to monthly publication recently effected has been a great step in the direction they desire and that it was not effected without considerable expense and some organising effort. The JOURNAL is a somewhat elaborate publication, but in spite of this it is the desire of those concerned in its conduct to comply as far as possible with the desires of its contributors and readers.

The Transactions.

The JOURNAL, for the future, will be what it has been in the past, a record of the proceedings of the Society and of the lectures read before it, together with such additional periodic information as can with advantage be included in a monthly publication. This, however, does not exhaust the needs of the aero-

nautical profession. Various matters have from time to time been submitted to the Society for publication of high scientific interest, but in a form obviously unsuitable for communication by the ordinary media. These will, as occasion arises, be henceforth published at irregular intervals, under the title of "Transactions of the Royal Aëronautical Society." The first number, "The Calculation of Stresses," by Arthur Berry, M.A., will be issued shortly.

University of London.

The Senate invite applications for the University Chair of Aeronautics tenable at the East London College, for three years in the first instance. Salary £800 a year. Applications (10 copies) must be received not later than first post on Monday, 7th July, 1919, by the Academic Registrar, University of London, South Kensington, S.W.7, from whom further particulars may be obtained.

FABRIC AND DOPE, WITH SPECIAL REFERENCE TO DETERIORATION OF STRENGTH AND TAUTNESS.

BY F. W. ASTON, M.A., D.SC., A.I.C., OF THE R.A.E.

ABSTRACT

The first part of the paper deals with the action of light in deteriorating the strength of doped and undoped linen aeroplane fabric. Sunlight is shown to be the only serious agent. A curve is given showing the change in rate of loss of strength throughout the year, the effect being very great in summer and practically negligible in winter. A comparison of the weathering properties of German and British material is given. Experiments are described which indicate the loss of strength is due to the action of ozone formed by ultra-violet light, the distribution of the destructive power in the spectrum corresponding very well with a photo-electric theory of the formation of ozone proposed by F. A. Lindemann. The efficiency of dyes and pigments as protective agents is shown to be excellent, but the latter are to be preferred on account of their effect in improving the tautness given by the dope.

The second part of the paper deals with tautness and its measurement, the more important methods are discussed, and a standard one proposed by which the tautness can be expressed directly as a tension. A description of the standard frames and the system of measurement of tautness at high humidities at present used at the R.A.E. is given. A theory to account for the tautening effect of dope is suggested.

At the beginning of the war little had been published concerning the functions and weathering properties of dope. It was known that when doped fabric was exposed the dope layer cracked sooner or later, and it seems to have been generally believed that deterioration both of tautness and strength was due to such cracking. As it was expressed at that time, "the dope cracked and let the weather get through to the fabric." Though clearly more or less correct as regards tautness, which is a function of the dope layer principally, we now know that as regards strength, which is chiefly due to the fabric, this idea is entirely wrong. It is not difficult to see why, for after all, under reasonable aerodrome conditions, the word "weathering" only expresses the action of four things—air, moisture, sunlight, and change of temperature. Air can get to the fabric on the undoped side, cracks cannot affect the results of temperature nor, if the dope be transparent, those of sunlight. Experiments have been actually carried out to find if clean water gave any appreciable deterioration, but the negative result obtained was a foregone conclusion, for in the process of retting before it is woven the linen is allowed to steep in water for very long periods. Nevertheless, at that time energies were largely directed to the preparation of flexible varnishes which would prevent the cracking of the dope layer, of which the flexible nitro-varnish called V.114 was notably successful; ordinary "carriage" or "boat" varnishes were also used.

As opportunities began to occur more frequently of examining old machines, a fact of the highest importance was noticed by several members of the Royal Aircraft Factory and probably by dozens of officers engaged at home and at the front on inspection and repair about the same time; this was that at whatever points the dope was covered with an opaque layer of paint, such as the number on the tail or the identification circles on the wings, there the fabric retained great strength, although all the unpainted part might tear like paper.

This suggested that the real cause of the weakening was *light*, a conclusion which has been abundantly justified since. The dopes with which these results were noticed were, of course, those made with tetrachlorethane; this compound is decomposed by sunlight, and it was quite possible that the chlorine and hydrochloric acid liberated was the real agent destroying the linen. As time went on and preliminary experimental results came to hand the action of light was seen to be more direct and fundamental, the abolition of tetrachlorethane for other and better known reasons made little, if any, difference to rate of deterioration, and long before the real causes were discovered practical prevention was achieved by a pigmented varnish of a dark khaki shade, known as P.C.10, the effect of which is very strikingly indicated in Fig. 1, which shows the progressive

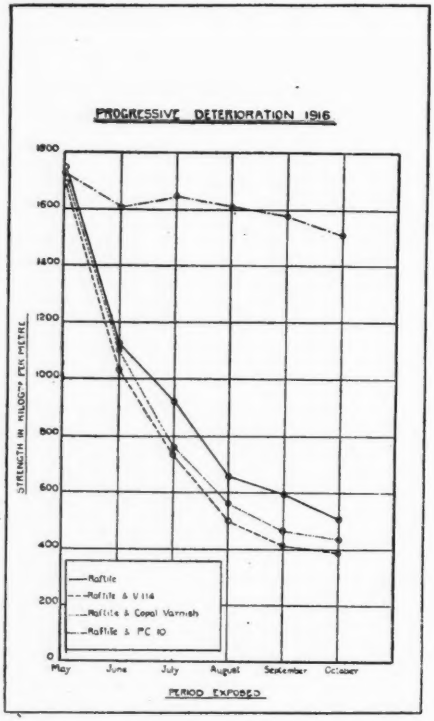


FIG. 1.

deterioration of varnished and unvarnished doped fabric exposed in the summer of 1916. Treatment and weight were as follow:—

Treatment	Mean Weight Grs/Metre²
6 coats raftite	196
,, ,, ,, 2 coats V.114	243
,, ,, ,, 1 ,, copal varnish	237
,, ,, ,, 2 ,, P.C.10	236

The frames were exposed on May 24th, 1916, four being brought in for strength tests on the 24th of each month following. The strength so obtained is plotted against time of exposure.

Fig. 2 shows the results of a similar series, including undoped fabric, started on January 16th, 1917.

Treatment	Mean Weight Grs/Metre²
Undoped fabric	130
Fabric + 6 coats raftite	186
,, ,, ,, ,, + 2 coats V.114	227
,, ,, ,, ,, + 1 ,, copal varnish ...	232
,, ,, ,, ,, + 2 ,, P.C.10	221

These curves indicate the enormous importance of an opaque covering, this being particularly striking in Fig. 1, as the exposures were started at a period when the destructive force of the sunlight was at a maximum. They also make it abundantly clear that, so far as strength alone is concerned, once the action of light is prevented, doped fabric is capable of sustaining continuous exposure for several years without dangerous weakening.

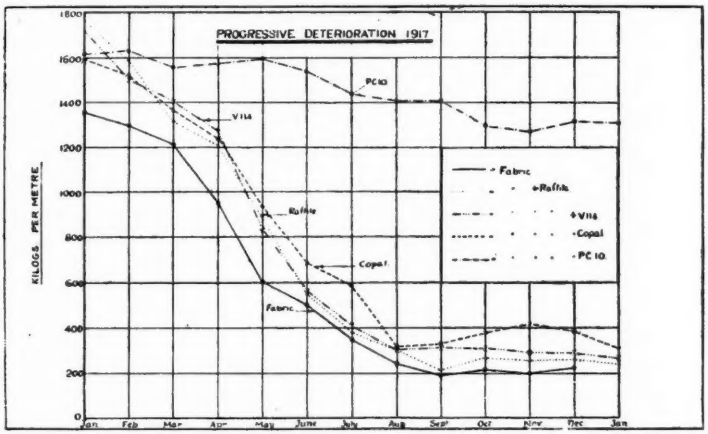


FIG. 2.

Rapidity of Deterioration at Different Times of the Year.

Towards the end of 1916 routine weathering tests on raftite produced at the R.A.F. showed such excellent concordance when exposed for the same period that it seemed quite probable that reliable values of the rates of deterioration during different seasons of the year could be obtained by their means.

As at least eight test frames (representing different batches of dope) had to be tested every fortnight, a mean of not less that 32 actual test strips could be taken for each period, which enabled the statistical error to be considerably reduced. After February, 1917, arrangements were made to expose the frames in comparatively large batches at the beginning and middle of each month. The period of all exposures was three months, a batch of weathered frames being taken in at the same time as a new batch was put out. The frames were exposed on a roof of the Chemical Department of the Royal Aircraft Establishment sloping south and facing the aerodrome.

Failing more accurate data, it was assumed that with a uniform deteriorating influence the decrease in strength would be logarithmic. A flat mean of 1,600 kg./metre was taken as the original strength of the unexposed material and the logarithm of the ratio of this to the strength after exposure was taken to represent a measure of the mean rate of deterioration for the period. The full line on the accompanying diagram, Fig. 3, represents the value of the logs so obtained,

plotted against the time of the middle of the three months period, *i.e.*, the height of the curve for a given point of time represents the log of the mean loss of strength by exposure from 1½ months before to 1½ months after that date.

The two comparison curves plotted in the same way, *i.e.*, three months' total plotted against mean data are:—Total radiation received on horizontal black surface of Callendar Recorder at South Kensington and the same determined by means of a Wilson Radiointegrator at Farnborough, the scale plotted being quite arbitrary in each case.

The similarity of the curves is very striking and affords strong support to the conclusion already arrived at, that deterioration in strength of fabric doped with transparent dope is for all practical purposes solely the effect of sunlight, also that weathering tests done in the winter months are absolutely useless, the rate of deterioration dropping to about one-tenth the summer value.

The most important divergence is the falling off in the rate of deterioration after the point represented at the end of May which throws the peak of the curve to a considerably earlier date than that of sunlight intensity. This may be reason-

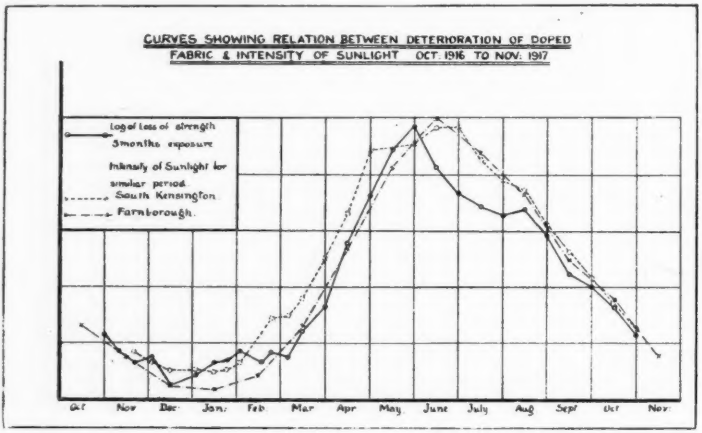


FIG. 3.

ably explained by the fact that the deterioration is caused by light of short wave length, which being more susceptible to scattering by haze than the rest of the sun's radiation, would therefore be correspondingly weaker in late summer; in this connection it may be noted that in 1917 the spring and early summer were exceptionally clear and bright.

The unduly high deterioration recorded at the end of January may have its explanation in the highly actinic light reflected from the snow which covered the aerodrome for long periods about that time.

An examination of the peak of this curve shows that unprotected doped fabric loses about 12 per cent. of its strength in a single *average* English summer day at sea level. The rate would be enormously greater at high altitudes above the clouds.

Comparison of German and English Dope.

It is interesting to note that rapid as this deterioration is, in the case of an enemy machine examined it was even worse. This was an Albatross Scout captured practically brand new, as dates stamped on parts of it indicated, in December, 1917. The fabric appeared to be flax, rather coarse, open and highly

calendered. It was camouflaged by a complete covering of highly coloured hexagons dyed on the fabric before doping. The dope was acetyl without protective varnish.

Pieces of doped fabric from the upper and lower surfaces of the lower wing were stretched on frames and exposed on the roof of the R.A.E. side by side with control frames of raftite, with and without protective varnish. Linen aeroplane fabric was used, and the raftite was of the six-coat grade, then issued in quantity by the R.A.E.

The exposure was started on February 1st and the frames taken in for test on May 1st. The mean deterioration rate for this period given by the curve for the previous year (see Fig. 3) is about one quarter that for the three months, April 16th to July 16th, *i.e.*, the exposure corresponds to only three weeks of summer weather, nevertheless the effect was surprising. The condition of the German dope was hopelessly bad; the camouflage dyes had faded considerably, the surface was a mass of tiny cracks, the dope coming off in powder when creased, all elasticity had disappeared, and it may be safely said that the machine would have been condemned for flying long before the exposure was completed.

The raftite, as routine tests led one to expect, was taut and elastic, it did not crack when pressed strongly by the thumb or even in creasing, the only change detectable being the bleaching of the fabric. The frames treated with protective covering P.C.10 showed no change whatever

The following table shows the results of strength tests, all test pieces being cut across the wings, *i.e.*, in the warp direction:—

		Before exposure.		After exposure.		
	Wt.	Strength Kg./metre.	Extension %.	Strength Kg./metre.	Extension %.	% loss of Str.
Albatross, Upper Surfaces	173	1417	5·7	763	4·3	46
,, Lower ,,	169	1463	7·0	699	4·1	53
Raftite	204	1728	12·3	1374	11·9	20
Raftite + P.C. 10	221	1757	13·2	1738	13·2	1

It is difficult to account for the extremely rapid deterioration of the Albatross except by supposing that very inferior materials had been used in the manufacture of the dope. The dyes do not seem to have afforded any protection.

It is interesting to note that the Germans do not appear to have adopted pigment varnish as protection from light, although many recent machines have been pigmented; this appears to have been done with a view to camouflage only.

Experimental Investigations into the Nature of the Action of Light.

Experiments extending over three years and involving thousands of strength tests tend to confirm the conclusion indicated by what has already been stated, namely, that deterioration in strength of doped or undoped linen fabric (sometimes called tendering) when exposed to ordinary service conditions is due to light and to light only, the effect of other agents, *e.g.*, heat, moisture, bacteria, moulds, etc., being quite inappreciable in comparison. It is therefore of great importance to investigate the mechanism by which the destruction is brought about.

As a physical study the problem is beset with difficulties. The material upon which the work has to be done, whether yarn or fabric, being a manufactured article is exceedingly variable in its properties, a defect greatly enhanced by the exigencies of the war, so that one is driven to the use of statistical results involving either large numbers of experiments or low numerical accuracy.

Again, it is difficult to imagine a more unreliable quantity than sunlight in this country, so that there can be no comparison between two tests unless they have been exposed for an identical period both in duration and date. The only artificial source of light yet used with any success is that of the quartz mercury arc, and this is found to be subject to serious objections. It is not therefore surprising that discordant or even contradictory results are occasionally obtained, and the greatest care has to be used to avoid erroneous conclusions.

The Distribution of Destructive Power in the Spectrum.

This was investigated by the direct method of throwing the spectrum of mercury arc on a series of linen threads, using for the purpose a Hilgar Quartz Spectrograph, kindly lent from the Cavendish Laboratory by Prof. Sir J. J. Thomson.

The method adopted was as follows:—

Two photographs of the spectrum to which the linen thread was to be exposed were taken on a ¼-plate in the ordinary way, one at the top and one at the bottom of the plate. The finished negative then had its edge carefully rounded off, after which the whole of the spectrum was covered by a binding of thread, the strands of which were carefully laid close together parallel to the spectrum lines. The thread used was Campbell's No. 70 special machine linen thread which had been washed free from size. As wound on the plate there were almost exactly three threads per m.m., rather over 100 being used to cover the part of the spectrum judged to be important.

The negative was now replaced in the plate holder of the spectrograph and exposed exactly as an ordinary plate, using the threads as a sensitive surface, the plate holder being in its median position.

When the experiment was originally planned, it was hoped that the loss of strength of each thread could be plotted along the spectrum, but this was not practicable owing to the impossibility of obtaining threads of sufficiently uniform strength, and also to the unexpectedly feeble destructive power of the dispersed light. Fortunately, however, there was available a much more delicate criterion, capable of giving useful results, namely, the observation of which threads broke at the point of application of the light and which broke elsewhere.

Even with the employment of this method, the first two experiments gave completely negative results although the exposure in the second was prolonged for 250 hours. In searching for the causes of the failure, one was soon found in the rapid falling off of ultra-violet efficiency of the mercury arc. A third attempt was therefore made, the conditions of which, as it was successful, will be now described.

The source of light was a Westinghouse Cooper-Hewitt Quartz Mercury Arc, type Z.2B., taking about 3.5 ampere at 200 volts. In order to obtain maximum intensity the burner was arranged parallel to the slit of the spectrograph upon which the image of the arc was projected by means of a short focus quartz lens in line with the collimator. A very open slit was used giving lines about 2 m.m. wide at the plate, *i.e.*, covering about six threads. The total distance travelled by the light in air was about 75 cms.

The duration of the exposure was 670 hours, at the end of which time the threads were stuck down to the plate with a little varnish at the point immediately opposite that exposed and then cut and tested one by one in order in a Baer thread tester. The breaking strain was recorded, but is of little interest in this particular experiment, the real criterion being whether or not the thread broke on the part exposed to the spectrum. The position of the threads relative to the lines of the spectrum was checked from time to time as the breaking tests proceeded, and the diagram showing the results is given in Fig. 4. The line of

circles represents the threads, those breaking on the spectrum being shown black. As the latter occupied about 1/6th the length between the jaws of the thread tester an average of one black circle in six is to be expected in the unaffected regions.

Above the threads are shown the lines of the mercury arc spectrum as a series of columns approximately six threads wide; the heights of the columns represent the relative intensities. In the case of the stronger lines where wave lengths are given, the intensities are those determined by Ladenburg, the others being estimated roughly from the strength of the image in the photographic negative. For reference a curve showing the distribution of intensity in sunlight is included. This is plotted from Abbot and Fowles values corrected for the dispersion of the instrument.

The experiment shows very definitely that the destructive effect of the light from the mercury arc of greater wave length than $\lambda = 3660$ A.U. is negligible. As there is a strong line at $\lambda = 4060$ it is perfectly safe to conclude that in sunlight or in a continuous spectrum the destructive effect cannot be serious for $\lambda > 4000$, in other words, visible light has little if any destructive effect. In

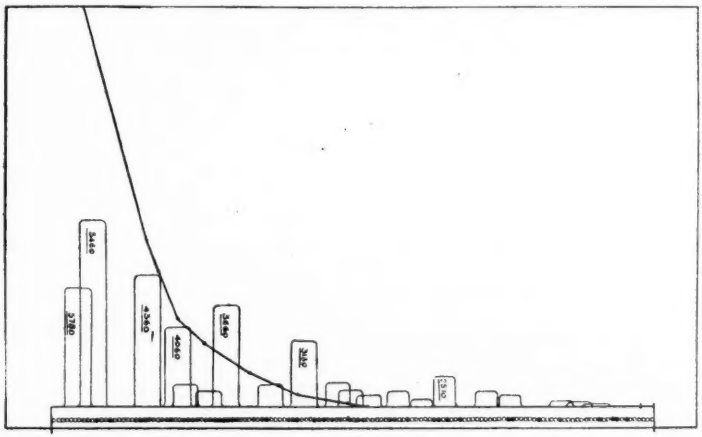


FIG. 4.

the direction of smaller wave lengths there appears to be no limit, and it is doubtless due to this that there is so great a disparity between the effects of the direct light of the lamp and that in the spectrograph. Thus, at a distance of 45 cms. the direct light caused a loss of about 20 per cent. per week, while the mean loss of strength over the whole dispersed spectrum for four weeks was inappreciable.

Some early experiments with the mercury lamp showed that its direct effect on fabric was enormously reduced by the interposition of a piece of window glass. Later it was found that glass did not reduce the effect of sunlight in anything like the same proportion. The explanation of this is that the glass cuts off all rays less than λ 3390, thereby reducing the destructive energy of the mercury spectrum to a much greater degree than that of sunlight which has but little energy below that wave length.

During 1918 an attempt was made to repeat this experiment, using sunlight to give the spectrum. The Astronomer Royal, Sir F. Dyson, very kindly permitted the spectroscope to be mounted on one of the large clock-driven equatorials

at Greenwich Observatory; the image of the sun was concentrated on the slit by a quartz lens, and after an exposure from April 25th to May 22nd, corresponding to about 112 hours sunlight, the threads were tested, but although bleaching was very evident no measurable loss of strength had taken place. This failure was partially explained later when it was found that doped fabric exposed at Greenwich deteriorated at less than half the rate of a control exposed at the same time at Farnborough. A very interesting result indicating that smoke and haze must have a much greater scattering effect on the destructive short wave length part of the spectrum than on the visible part generally. Another attempt was made from May 22nd to September 6th, using a rather more sensitive cotton thread instead of linen, but this also gave an entirely negative result, so that the actual distribution of destructive power in the sun's spectrum has not yet been experimentally determined.

The Influence of the Atmosphere Surrounding the Fibres.

As ozone and H_2O_2 have long been suspected of being the principal agents in the deterioration process, experiments in which oxygen and water are partially or wholly eliminated are of interest.

The first experiment of this kind consisted in exposing strips of aeroplane fabric to the light of the mercury arc in a box with a quartz lid and comparing their loss of strength when air or hydrogen was passed through the box. It was found that a loss of strength of 20 per cent. in the case of air was reduced to 6 per cent. in the case of hydrogen. The method of experiment has been greatly improved by the use of linen threads instead of fabric strips, so that more test pieces can be taken and several different experiments can be exposed to the lamp at the same time and so can be regarded as strictly comparable.

The procedure consists in winding the thread on glass as in the spectrum experiment. A narrow strip of glass is taken, carrying about 30 test threads, and thick tinfoil is wrapped over the ends so that only the half inch at the centre of each test thread is exposed to the light. Test strips of this kind can be slipped into 15 m.m. transparent quartz tubes in which they can be subjected to any treatment desired, very much more conveniently than in the large box with quartz lid previously employed.

The following is a typical set of results. In this case four sets of threads were used, all being placed in similar quartz tubes. One of these tubes was open at both ends so that air was free to circulate, the second contained phosphorus pentoxide at one end; it was highly exhausted for a considerable time in order to render the threads as dry as possible and then filled with dry air. The third was exhausted to very high degree of vacuum on a Gaede Mercury Pump with repeated warming and then sealed off. In a fourth was put a control strip of threads completely covered with tinfoil. The four tubes were placed under the mercury arc at a distance of about 23 cms., a thermometer was laid between them which rapidly rose to 59° C. (a temperature which does not usually affect the strength of linen yarn) and then remained steady throughout the exposure. After an exposure of 72 hours the threads were tested and position of break noted, the statistical percentage of breaks between the marks in unexposed threads being about 16.6 per cent.

	Thread Campbell's No. 70, not Washed.		
	Mean strength.	Percentage loss of strength.	Percentage of threads breaking on part exposed.
Air (not dried)	52.2 oz.	34.4%	100%
Air (dry)	52.3 ,,	34.2%	100%
Vacuum	71.5 ,,	10.2%	62%
Check in darkness ...	79.5 ,,	—	16.6%

The conclusion from these and other similar experiments is that the removal of oxygen from the atmosphere surrounding the fibres very largely reduces, but does not entirely eliminate the destructive action of the light. The presence or absence of moisture does not seem to be important.

Photo-Electric Theory for the Action of Light.

It will be seen that there is evidence that ozone or oxygen in some active state is the most important factor in the destruction of linen fibres by light. Lyman ("Spectroscopy of the Extreme Ultra-Violet," p. 67) has shown that light causing the direct formation of ozone in air must have a wave length less than 1850 A.U. and that it is completely absorbed by 1 m.m. of air at atmospheric pressure. It is therefore quite impossible that any appreciable quantity of ozone can be formed by the direct action of sunlight on the air near the earth's surface. How then can we account for the production of ozone on or in linen fibres. A possible explanation has been suggested by Dr. F. A. Lindemann which may be briefly explained as follows:—

The most effective frequency ν for ionising a gas is given by $h\nu = eV$, h being Planck's constant, e the electronic charge and V the ionisation potential. If we take $V = 9.0$ volts, the value obtained by Frank and Hertz, we get $\lambda = 1380$, a value agreeing very well with $\lambda = 1350$ according to Hughes (v. Allen, "Photo-Electricity," p. 90), but the energy required to remove a charge e to infinity is of the form e^2/kr where k is the dielectric constant of the medium* and r the radius of the molecule, so that the most effective wave length in a medium of dielectric constant k will be k times that in oxygen itself, of which the dielectric constant is nearly 1. Hence, if we can determine k for linen fibres, the most destructive region of the spectrum can be roughly predicted.

A direct determination of k is impossible, but since it equals the square of the refractive index, it can be calculated if the latter is known. By the method of immersing the fibres in liquids of various refractive indices a value for linen fibres of 1.53 has been obtained. From this $k = 2.34$ which gives a wave length $\lambda = 3,230$ in good agreement with the actual results given above.

It will be seen that this special reasoning only applies to molecules of oxygen which are actually in close contact with or absorbed by the fibres. Such molecules would be exceedingly difficult to remove entirely by pumping or washing with another gas, so that a possible explanation is supplied for the incomplete immunity found in a vacuum or an atmosphere of hydrogen.

Methods of Protection of Fabric from Sunlight.

Dyes.

At the time the investigation of the best method of protection was started, owing to the failure of earlier attempts (a failure possibly due to the presence of tetrachlorethane), it was not thought possible to pigment a dope without spoiling it. Dyes were therefore experimented with, and out of about 150 soluble in dope about half a dozen gave promising results, of which two blacks and one yellow gave practically perfect protection and did not fade. Raftites containing only 1 per cent. of such dyes gave a decrease in strength of less than 15 per cent. over 12 months' continuous exposure, *i.e.*, were as good as the best P.C.10, and had strength alone been of importance, dyed dopes would have been strongly advocated, but tautness was equally so and the possibility of its deterioration being also due to the action of light (and therefore to be minimised by dyes) was not realised. In addition, Dr. Ramsbottom discovered that raftite (which contains no tetrachlorethane) could not only be successfully pigmented but that such

* As the distances with which we are concerned here are comparable with molecular interspaces, k will not have its ordinary statistical meaning, but its numerical value will probably not be very different.

pigmentation enormously improved the qualities of the dope as regards tautness (v. Figs. 9 and 10).

Pigments.

The most important properties of a pigment used for protection either in a varnish or a dope are (*a*) it must have a high extinction coefficient for the actinic light, (*b*) it must be capable of extremely fine grinding, for it is obvious that a given weight of pigment will cover an area directly proportional to its fineness, (*c*) it must be chemically inactive to any of the constituents of the medium. The natural oxide of iron, known as ochre, which was one of the first tried at Farnborough, possesses all these properties to a notable degree, and when in addition one considers its cheapness and the fact that by the addition of a little lamp-black it yields a khaki shade, it is not surprising that its use as the main constituent of pigmented varnishes and dopes is almost universal. For tropical work aluminium has much to recommend it.

Tautness and its Measurement.

Tautness of doped fabric is important in a great variety of ways. Aerodynamically it is essential to reduce the sag to certain limits, but it is probable with the materials now in use that any surfaces deteriorating to a slackness sufficient to affect the aerodynamical properties of the machine seriously would have been condemned long before on their appearance, though with sufficiently elastic and extensible material this might not be the case.

Appearance is actually a very important consideration indeed. One cannot expect a pilot to view with favour a machine with its fabric hanging in reefs however good it is in other respects, also slack fabric when in flight, and particularly when exposed to the slip stream of the propeller, may get into a state of flutter, the violence of which may tend to increase and lead to its complete collapse.

Another point which has been somewhat neglected is how very greatly the strength of the wing structure is influenced by the tension of the doped fabric upon it. In general, slackness of the dope will weaken the strength of the wing structure, but on the other hand too great tautness will lead to deformation or even fracture. There seems little doubt that were we able to guarantee a definite tension constant in all weathers and conditions, sweeping improvements could be made in wing design.

Method of Measurement.

Direct measurement of the tension of doped fabric can only be carried out with elaborate apparatus and is quite out of the question as a practical method; one must therefore rely upon indirect methods. Of these a great variety have been suggested, nearly all depending upon the application of a force normal to the surface under consideration and the measurement of the relation between this force and the resulting displacement.

Thus, since 1916 comparative measurements of tautness have been obtained in this laboratory by placing a small sphere at the centre of a standard frame, loading this with a known weight (100, 200, or 400 gms.) and measuring the consequent depression with a cathetometer. This "depression" method is quick and delicate and works well for comparison of dopes, but as the mathematical relation between the stresses in the material and the depression measured is extremely complex, it is unsuitable as a standard method. It is also obvious that it can only be used on test frames of exact dimensions.

The G.A.C. Aero Tensionmeter.

In this instrument the last objection is overcome by the instrument in a sense supplying its own frame in the form of its heavy circular brass rim, which rests

on the doped or undoped surface. The depression of a specially designed disc at the centre of this circle is applied by a standard spring and measured by an Ames dial gauge. This instrument is simple and portable, it also possesses the great advantage that it can be used upon aeroplanes direct.

There seems little doubt that the irregular readings (v. Fig. 7) obtained with the instrument are due to two causes, the friction in the Ames dial gauge, which can be eliminated sufficiently for practical purposes by the use of some such device as that described in the spherometer below, and the friction between the brass rim and fabric surface upon which the isolation of the circle depends.

In working out a formula for the instrument Dr. Silberstein has assumed the latter to be infinite; to give consistent results it is enough for it to be constant, while in practice approximately reliable results can only be obtained by judicious tapping which makes it virtually zero.

In order to get a rough idea of the real value of the coefficient of sticking friction, the instrument was placed on various surfaces and pulled in a horizontal direction by a spring balance. From the readings of the balance when slipping just started and the weight of the instrument (1,200 gms.) the following values were obtained:—

Surface.	Coefficient of Friction.
Undoped fabric	·375
Raftite unweathered	·400
Raftite weathered	·375
Dope weathered and badly cracked	·568
Pigmented dope unweathered	·465
P.C.10 unweathered	·393
Emaillite pigmented oil varnish weathered	·400
Emaillite pigmented oil varnish unweathered ...	·67 — ·85*

As the rim has a circumference of 47 cm. the difference of tension between the inside and outside necessary to cause slipping is approximately 10 gms. wt./cm. The extension caused by the depression of the plunger at the centre for ordinary doped surfaces requires a force of about the same order, so that it is doubtful if an instrument working on this principle is suited for the accuracy required in the laboratory, but as regards its use on planes direct, its portability and simplicity are strong points, which, together with the fact that it can be used on undoped fabric should render it an extremely useful instrument for technical inspection work.

Standard Method of Measuring Tautness.

There seems little doubt that the best method of applying a measurable force to doped fabric is in the form of a fluid pressure. If air is taken as the fluid and the pressure chosen properly the surface is approximately under actual flying conditions; the measurement may be made independent of the size or even the shape of the frame, and when obtained can be expressed in such a way as to give direct mechanical information to the designer.

In consequence of these suggestions submitted to the meeting held July 26th, 1918, the Dope Panel of the Engineering Standards Committee adopted provisionally the following definition:—

"That tautness T of a doped surface shall be defined as the evaluation of the expression

$$T = \frac{RP}{2}$$

where R is the radius of curvature when a difference of pressure P is maintained

* Depending on how long the instrument was allowed to rest on the surface before the pull was applied.

between the sides of the doped surface, that the difference of pressure should be as nearly as possible 1in. of water (2,490 dynes/cm.^{2}) and that the value of the tautness should be expressed in lbs. per inch or kilogrammes per metre."

The *tautness* expressed in this way, though not strictly the same as the *tension* of the surface, is sufficiently so for all practical purposes, hence a designer being given the tautness under various weather conditions can calculate the stresses he may expect to be caused in the structure of the wing by the doped fabric covering it.

It will be seen that the definition above makes no restriction as to the method of applying the difference of pressure or measuring the curvature.

The method recommended is that airtight frames should be used, the pressure inside reduced to one inch water below atmospheric by means of a filter pump and Mariotte bottle and the radius of curvature determined by a spherometer.

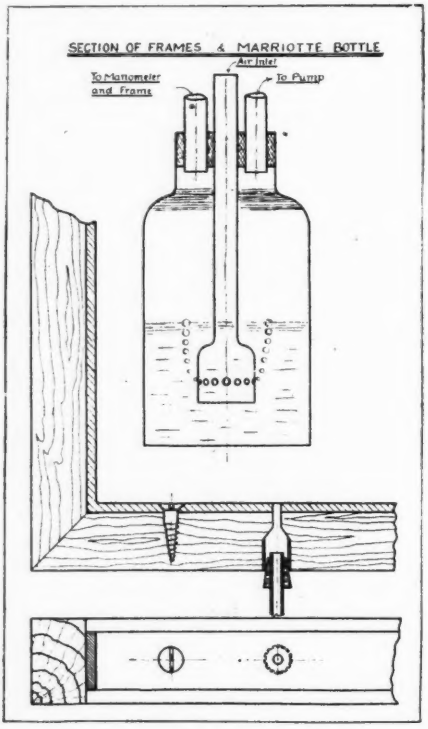


FIG. 5.

Standard Frames.

The form of frames adopted at the R.A.E. for all weathering experiments requiring determination of tautness is square 12in. × 12in. external dimensions built up as indicated in Fig. 5, the wooden sides 1in. thick and 1.5in. deep being reinforced as shown by a strip of iron 1in. wide by $\frac{1}{8}$in. thick bent into a 10in. square and welded up.

The frame has a permanent back of doped fabric and the fabric for the experiment is stretched over the front of the frame at constant tension (2lbs. per inch warp, 1lb. weft) and doped down to the wooden face of the frame. When dry

the edges are pulled over and stuck down to the outside edges of the frame with V.114. This method, which does away with nails altogether (except one at each corner to secure the loose flaps of fabric), has proved the best yet devised to prevent slipping.

For use with the spherometer tautness meter the breathing holes normally pierced through the back are replaced by a single one 3/16ths inch wide, through one of the sides. The outer part of the hole is enlarged to a width of $\frac{1}{2}$in. and lined with a short piece of brass tube driven flush. By means of the small tube and rubber stopper shown, airtight connections with the interior can be made easily and rapidly. At the same time the exterior of the frame is left free of any excrescences or alterations in dimensions. There is no difficulty in obtaining air-tightness sufficient for tautness determinations, small leaks being negligible.

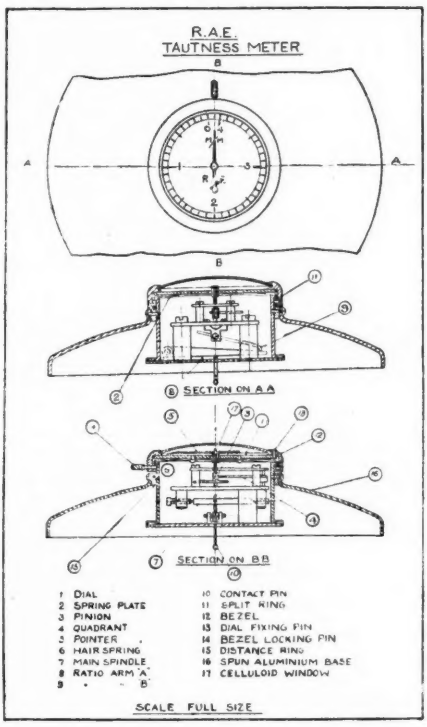


FIG. 6.

Method of Obtaining Constant Difference of Pressure.

Several devices were tried in the hopes of finding something more satisfactory than the Mariotte bottle, but without success. The form of the latter giving the most constant results is shown in Fig. 5.

The air overflow consists of a ring of $\frac{1}{8}$in. hole in a 1in. metal tube. It seems practically impossible to arrange for the device to be entirely independent of the rate at which the air overflows, so that the rate of exhaustion should be kept as uniform as possible.

The pressure is measured on a separate manometer and is exactly adjusted by sliding the air overflow tube through the cork. Small momentary variations

of pressure causing unsteadiness of the manometer may be damped out completely by the introduction of a large capacity between the Mariotte bottle and the manometer—an empty dope frame does very well.

The Spherometer.

This instrument, which was designed by the R.A.E. Instrument Department, is illustrated full scale in Fig. 6. By means of a specially arranged movement modified from that of Clift air speed indicator, the depression of the contact pin 10 below the level of the edge of the circular base 16 is measured on a horizontal dial graduated in m.m. and divided in tenths, which division being large may be easily subdivided by eye if necessary.

It is as well to state here that a horizontal dial is very much more convenient to read than a vertical one as fitted at present on the G.A.C. tensionmeter, which might be altered with advantage. This movement is practically frictionless and the spring necessary to take out backlash is so weak that its effect in depressing the contact pin beyond the point at which it just rests on the doped surface is negligible in cases of ordinary tautness, neither is the weight of the instrument, 205 grms., sufficient to cause any serious disturbance, so that it acts simply as a spherometer. The zero is obtained by placing it on a truly plane surface and can be adjusted by rotating the scale.

Owing to the desirability of keeping the scale uniform, the depression h is read in m.m., its reciprocal being a measure of the tautness for

$$T = \frac{RP}{2} = \frac{PD^2}{16\,h} \text{ (for small curvatures).}$$

D being the diameter of the spherometer rim 152 m.m. Hence, the tautness T is obtained by dividing a constant (determined for the instrument) by the reading on the dial expressed in m.m.

With this particular instrument the constant is 34.3 for T in kg./metre and 1.92 for T in lbs./ins.

As soon as the interior of the test frame is at the correct pressure it is only necessary to place the spherometer on the frame to obtain the reading. Naturally a central position is desirable, but no particular care need be taken in this respect as so far all doped fabrics tested were found to approximate remarkably closely to a spherical surface when submitted to the standard pressure. It is for this reason that the instrument gives quite reliable results even with a slightly warped frame, although it does not necessarily read zero when placed on such a frame before the pressure is reduced.

Comparative Results.

Fig. 7 shows results obtained on frames of various tautness by the depression method and the G.A.C. tensionmeter plotted against the reciprocal of the tension as determined by the spherometer method. It will be seen that the curve given by the 100 gram weight is not so nearly a straight line as that given by the 400 gram, but the latter passes further from the origin. The G.A.C. tensionmeter gives an irregular series of points, the locus of which is definitely straighter than the other two curves, from which it would appear that this instrument if calibrated to read the reciprocal of tautness direct would have a uniform scale—a great advantage.

Corrugations or Reefs.

These appear whenever the tension in any direction becomes less than 0. They were a source of serious error in the "depression" method as the centre of the frame might be a crest or a hollow of a corrugation which made a considerable difference even if a 400 gr. weight was used.

The spherometer method apparently does away with this difficulty entirely and as many of the most interesting comparisons of dopes are made under conditions of humidity which cause corrugations to appear, this is one of the most important advantages of the air pressure method.

Limitations of the Method. The Sphingometer.

It will be seen that although independent of the size of the frame, this is essentially a laboratory method as the latter must be reasonably airtight. It is therefore not directly applicable to the measurement of tautness of undoped fabric or to actual parts of aeroplanes. For the first only the roughest measurements

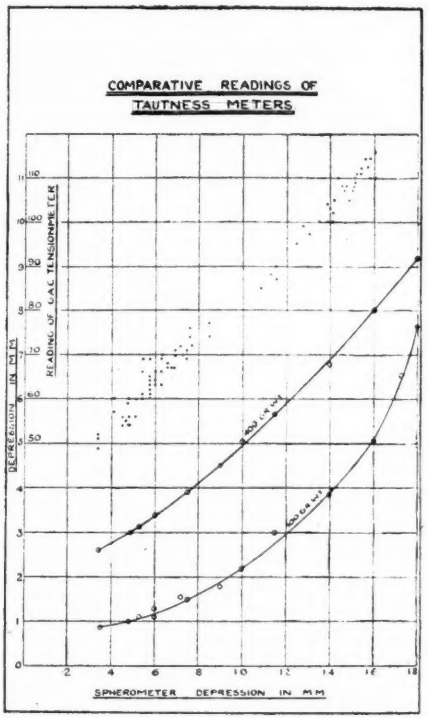


FIG. 7.

are necessary, as experiments have shown that variations of the tautness of fabric before doping over a very wide range have practically no effect on the final tautness of the doped material, so that an instrument of the G.A.C. type will probably serve all requirements.

In order to apply the air pressure method to any doped surface without regard to the structure upon which it is stretched, Dr. Barr, of the N.P.L., has devised an instrument which he calls the sphingometer. The accuracy of the results of this unfortunately depend on the frictional isolation of a circle of doped fabric by the rim of the instrument. Dr. Barr claims that this isolation is good, but a calculation from the values of frictional resistance given on page 223 shows that it is still of the same order as the forces tending to cause slipping; it is therefore quite impossible to guarantee either complete sticking or complete slipping.

It may be possible in the future in instruments of this type to render isolation certain or, by replacing the solid rim by a ring of rollers, to eliminate it altogether, but until this is done they cannot be recommended for accurate work.

Rigidity Effect.

It was suggested by a member of the A.I.D. that a considerable part of the resistance to depression of a doped surface might be due to *rigidity* as distinct from *tension, i.e.*, the surface might act as a piece of cardboard loosely resting on a frame would do. Although it seemed very unlikely that this force would be serious, a direct measurement was made by testing strips of doped fabric, 10 × 3 cms., clamping one end in a vice and measuring the bending—mean of results in opposite directions—caused by a small weight placed at the end.

In this way the pressure found necessary to cause the curvature obtained in ordinary measurements of tautness by the spherometer was roughly .02 cm. water, *i.e.*, less than 1 per cent. of the total, so that the rigidity effect is quite negligible.

Accuracy of Tautness Measurements.

Accuracy is only desirable or indeed possible in comparing dopes directly in the laboratory, and here the utmost hoped for is about 1 per cent. The reason

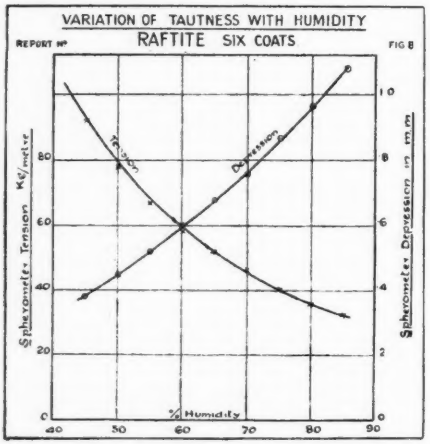


FIG. 8.

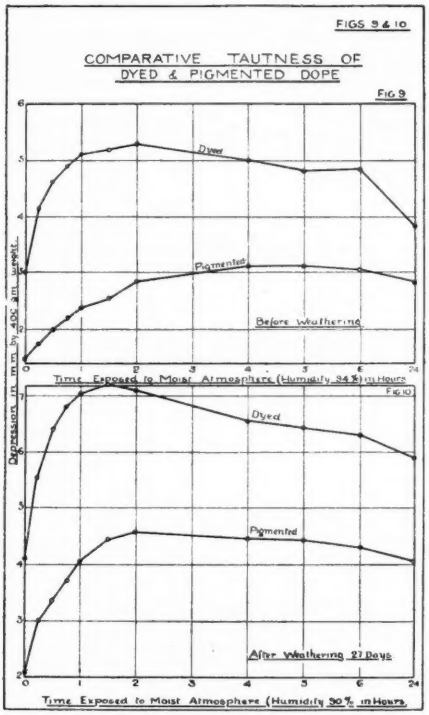
for this is easily seen in the extreme sensitiveness of dopes in use at present to changes of moisture. Fig. 8 shows the change in tautness in fabric coated with six coats of standard raftite under varying humidities. Measurements of tautness under ordinary laboratory conditions are not of much value; the relative merits of dopes are only to be gauged by taking their tautness at various humidities and particularly near saturation point—it is for this reason that the dial in the spherometer was given the very long range of 4 m.m.

The method of doing this at present in use at the R.A.E. is to place series of test frames in an enclosure kept constantly at the highest humidity possible, generally over 90 per cent., and measure the tautness after various intervals of time. As may be imagined this is laborious, but at present it seems the only method giving really valuable information. Figs. 9 and 10 show some typical sets of readings (using depression method), those given by the dyed dope—which may be taken as identical with undyed raftite—being very markedly inferior to those of the pigmented one.

Experience shows that the peak of the curve representing slackness rises progressively with age and exposure, but the tautness of the frame under moderately dry conditions shows very little change, hence the older the doped surface of an aeroplane the greater will be the change in its tautness when exposed to wet weather, or more accurately, damp air; to this of course must be added the inevitable slackening caused by the gradual yielding of wing structure.

Mechanism of Tautening by Dope.

No adequate explanation of this has yet been worked out. The simplest one



Figs. 9 and 10.

is to suppose the dope is a fluid of which the viscosity steadily increases with drying. As it reaches higher and higher values greater and greater forces will be necessary to prevent uniform contraction in all three dimensions due to decrease in volume, so that if it is in the form of a flat plate great forces will be applied to the edges if these are held immovable.

In order to see if this simple explanation is probable it is only necessary to dry two frames of the same dope at greatly different rates. If the viscosity changes gradually and never becomes infinite this treatment must inevitably give a difference of tautness. An experiment of this kind was done at the R.A.E. in which the time of drying was varied from a few minutes to ten days. The tautness obtained was identical in each case.

It therefore seems more probable that some time before complete dryness is obtained infinite viscosity is reached, *i.e.*, the dope becomes a true solid. In

support of this view results obtained by Mr. Mardles at the R.A.E. recently may be quoted. In investigating the solution of cellulose acetate he has found that in practically all dopes at a certain stage of concentration perfectly definite and depending on the solvents the acetate comes out of solution. The structure of the solid so formed is not known, but if, as appears likely, it is a three dimensional lattice, the further evaporation of the fluid in the lattice will give rise to exactly the tautening effect observed, the final tautness being independent of the rate of drying.

Future Research.

As deterioration of strength has been virtually abolished the next desideratum to be attained is uniform tautness not changed by weather conditions or age. We are still far from this ideal, as cellulose acetate is exceedingly sensitive to moisture, but pigmented dope is a noteworthy step in this direction and an explanation of the remarkable change in properties given by pigmenting will probably lead to further progress, the direction and extent of which it is impossible to predict.

Farnborough, January, 1919.

COMMERCIAL AND PLEASURE FLYING.

BY CLAUDE GRAHAME-WHITE.

May I say how glad I am to have this opportunity of speaking to you on a subject to which I, and others, have devoted so much time and thought. Not that any of us have ever begrudged this time or labour. Far from it. I myself, after twelve years as a student of aeronautics, cannot look back on any period when, even for a moment, I have wearied in my task. And indeed the more I study this subject the more convinced I am how well worth while it is for us, now, to devote all the time we can to this question of commercial aeronautics. It is a subject which is something much more than purely commercial. It is not only national but also Imperial. It is something even more than both of these; it is a question which affects the development, happiness, and peace of the entire world. When, with the growing speed of aerial transport, we shall be able to dine in New York one evening and in London the next; when no part of the earth's surface, however remote, is more than a week's journey from London by air, then I think we may say that the coming of this aerial age will do more for the world than any other invention or discovery man has ever made.

Temperament and Flying.

The temperament of our race, which has sent us adventuring throughout the world for centuries, proves ideal where flying is concerned. It contains a very rare mingling of just those two qualities which are more valuable than any others—courage and caution. The Briton, when he is flying either in peace or war, does so with a personal and sporting zest. He flies an aeroplane as he would ride a horse to hounds, or in a steeplechase, or sail a yacht in a freshening wind. It is sport to him—an adventure! And it is this spirit which renders him as invincible in the air as he has been for centuries on the sea. The Briton is a born sailor, and has all the traditions behind him of a great seafaring ancestry. And much that appertains to the sea appertains also to the air—a knowledge of winds and weather; a faculty for navigation; an instinctive alertness of mind; and the power of a quick, unflurried decision.

Therefore the whole tradition of our nation, with its great sea history, tends to produce fine airmen. And it should be gratifying to us, standing as we do now at the dawn of the air age, to know that however keen the race for air supremacy may become, we shall be able to produce men of the very best kind to handle the machines that our constructors will build.

Our ocean supremacy has been due mainly to our magnificent seamen; and we shall always be able to find the men—don't doubt that—who will secure for us, and then maintain, a supremacy of the air.

What we must now contemplate is that the whole of the high speed transport of the world will be transferred gradually from land and sea to air. This is no longer a romance; it is a change which will come about in a definite period of years; and just how long this will be depends mainly on the initiative of the public in making use of the aerial services which we shall now so soon be operating.

We must accustom people to the idea that when they are called on to make an urgent journey, or when they wish to send an important letter, or parcel, an aerial service, in preference to the railway service, is now at their disposal. We want to make people think about these new air services. We want them to become familiar in their minds with the idea of travelling by air, just as they are familiar with the idea of travelling in a motor car or train. And here the Press, if it will do so, can help us enormously. By keeping commercial flying constantly before

the public, and by showing them how practical it has become, the newspapers can render our movement the greatest possible assistance; and I do not think we shall have to appeal to them in vain.

The spirit of reconstruction with which we enter on the era of peace now dawning, the desire to make the fullest use of our time, to scrap old ideas and welcome new ones, will help very greatly in the development of commercial flying. Time is money; and with huge tasks now facing us, and when every minute means more to us than it ever did before, we should find people only too ready to travel from London to Paris in three hours, by air, instead of wasting seven or eight on the journey by land and sea; to say nothing of the discomforts of a bad sea crossing, which is dreaded so much by many travellers.

The Three Essentials.

I am now confronted by the three questions I am so often asked. These are:—

Firstly—Can an air service be made safe?
Secondly—Can it be made reliable?
Thirdly—Can it be made to pay?

These are the essentials, and all I ask is that my hearers should approach the subject with an open mind. They should bear in mind what we have accomplished in aeronautics within only a comparatively few years. It was only eight years ago that I was told again and again it would never be possible to fly an aeroplane in bad weather; while a good deal more recently even than that, I, and others, were told that an aeroplane, owing to its frailness and alleged unreliability, would never play any really useful part in war. Well, I think the performances and accomplishments of aircraft generally have, during the war, conclusively and satisfactorily disposed of any misgivings in both of these respects. Aeroplanes can now fly quite safely through a gale of wind and other adverse weather conditions. They have just had a vitally important influence on the greatest war in history; and when I tell you, as I shall now, of the important part aircraft are going to play in developing the commerce of the world, I think that on their record, and on the actual achievements they have scored, I am fully entitled to an open-minded hearing.

The aeroplane is the fastest vehicle in the world and is likely to remain so. The air is our ideal speedway. But speed alone is not enough. If it cannot be combined with safety, and with an ability to fly regularly to a daily time-table, then the use of the air will be irregular, and air services will be unable to compete with other methods of transport.

Nor must we ignore the important question of finance. The operation of an airway must be commercially sound. In short it must be made to pay.

However, before I go more closely into these questions, I think it would bring my subject nearer home to you, and would give it more actuality, if I illustrate and describe one of the passenger machines we are now designing, and shall hope quite soon to be running, on the air service between London and Paris.

SLIDE ONE (see end pages).

This machine is a logical development of such aircraft as we have been using for bombing. It can be built immediately, and will carry between London and Paris, non-stop, 24 passengers, housed in these comfortable compartments. In addition to these passengers there will be a crew of five persons—a pilot, a navigator and directional wireless operator, a motor mechanic, and an attendant in each of the passenger cars. In addition there will be a space in the rear of each of the passenger cars for 250lbs. of express parcels.

The engines are installed in this central nacelle, where they can be carefully attended to by the mechanic in charge. And I think this will be a great improvement on the haphazard dumping of engines at any convenient spot on the con-

struction of a machine, as has been the practice during the war. This practice of placing engines out on the planes has been mainly done for convenience, rapid installation, weight-saving, and air-screw efficiency. The method made it quite impossible, however, to effect any temporary repairs to motors while in the air, or indeed to in any way supervise their running. This machine here provides for the installation of the whole of the power to drive the machine being concentrated in one engine-room, placed centrally. The plant consists of three 600 horse-power motors, each driving a separate propeller, and the power of two of these engines is transmitted from the engine-room to the tractor air-screws, which I indicate here, by means of hollow steel shafting and gearing. A third engine drives a pusher air-screw which you can see at the rear of the engine car. There is, of course, a small percentage of loss in transmission due to this gearing, but with modern engineering principles this is reduced to an almost negligible quantity. The system also has the advantage of eliminating to a large degree any noise or vibration which might cause discomfort to the passengers in the machine. It has the additional advantage of distributing the weight fairly equally over the surfaces of the planes, which for technical reasons is desirable.

I will now show you a slide of the interior of the engine-room.

SLIDE TWO (see end pages).

Here, in front, you see a compartment set aside for the navigation of the machine. Right in front, with a clear outlook on all sides, is the navigating officer. His task will be to direct the course of the machine. He will have, first of all, to set the course and then to inform the pilot should there be any deviation from it. He will also, as I have had suggested in the slide, act as wireless operator, receiving such messages as to meteorological conditions as will be in constant circulation upon the airways; and also talking to main and terminal aerodromes, as a flight proceeds, and announcing the position and pending arrival of his machine. When necessary, also, he will correct his course by means of directional wireless. Behind the navigator sits the pilot. On the other side of the bulkhead, which has been cut away for the purposes of this picture, is the main engine-room. One engineer only will be carried. You see him standing here, near the switchboard.

I will now show you an interior view of one of the passenger nacelles, so that you may gain some idea of how you will be accommodated, and how comfortable you may expect to be, when you make a journey from London to Paris by air in a machine which has been designed specially for such a passenger service.

SLIDE THREE (see end pages).

This view shows that each compartment carries twelve passengers, six on either side of a central passage-way.

These passenger cars are fitted with side windows or portholes so that each passenger will have a view outwards during the progress of the flight; while in the front of the car, as you will see suggested in the slide, a small observation platform is provided. Here passengers may, if they wish, have an excellent view on all sides. In these big aircraft, I should mention, there is no question of any such fine balance as might prevent passengers from moving about while a machine is in flight; they will be able to do so quite freely.

We shall be able to find room in each of these cars, in addition to an attendant, for a certain weight in the form of light refreshments to be served en route, and also for other conveniences of modern travel. It would be pleasant on the afternoon air service from Paris to London, or vice-versa, to serve tea say at about mid-Channel; while on the morning services there is no doubt that a cocktail, some time during the flight, would be appreciated by many passengers. We must not forget the amenities of life, even when in the air.

I want to show you one more picture of a machine; and after that I shall deal with the questions of safety and reliability.

SLIDE FOUR (see end pages).

Here is a small machine which should play a prominent part in the early development of our airways. This machine is designed specially as a high-speed mail carrier for the transport of not more than 100lbs. of express mails. A machine of this description will have a speed of 170 miles an hour, and will therefore be capable of covering the distance between London and Paris in an hour and a half. Such a machine as this, owing to its very high speed, would be able to operate in the most adverse weather conditions, at any rate as regards wind or rain. Although the load carried might appear at first sight to be very small, it actually represents 3,200 letters of ½oz. each.

I venture to think that, even if the rates for such a service were high, they would be readily paid by anyone whose letter was really urgent. It would often be an enormous convenience, for example, if a London business man could come to his office in the morning and despatch an express letter to Paris, and for this letter to be received and answered so quickly that the reply came back well before the close of the business day. No such convenience as this exists at present, and I believe that business people would soon learn to make use of it. It should be possible, before long, to establish a network of these express air mails and to arrange return day services between cities as far distant as London and Glasgow. Nor does 170 miles an hour, the maximum speed I have just mentioned, represent by any means a limit. It is merely the performance we may expect immediately. Later on, as experience grows, I feel certain we shall have speeds by air as great as 200, 250, and even perhaps of 300 miles an hour; though I realise quite well that before such huge speeds are possible we shall have to pass a good many more milestones on the road to constructional perfection. Some of the problems in high-speed flying I should like to have mentioned, but they are so technical that I should have to enter into long explanations, and for these I have not time. I have often stated, however, and I take the opportunity here of stating again, that I am confident we shall eventually travel by air at a speed as great as 250 or 300 miles an hour. As to the comfort of passengers moving at such great speeds, and at very high altitudes, this can be ensured by the use of specially-designed, totally-enclosed saloons, in which the air supply can be made independent of the changes in atmospheric pressure outside. What we must never forget is that it will be the speed of aerial travel which will bring us our commercial loads of both passengers and goods. Therefore our motto in the aircraft industry must be "Speed with safety." I think, while still on the fringe of technique, I should mention the possibilities which lie before large rigid airships. I confess quite candidly I have had no experience with this type of craft; therefore my testimony can bear little weight. Yet I do feel, all the same, that one should recognise that there is now a great future before these big, rigid airships, particularly on trans-ocean flights, or on long journeys over undeveloped countries. A great deal has been done during the war to improve lighter-than-air machines, and yet they remain in a far cruder state of development than the aeroplane. Therefore we must expect that important progress will soon be made, and that before long we shall see on the trans-Atlantic route airships not only very much greater in size than any which at present exist, but attaining also an appreciably greater speed.

Now I have shown you two typical post-war machines. One will carry twenty-four passengers and 500lbs. of express parcels, and will do the journey between London and Paris in less than three hours; the other will carry an express letter between the two cities in an hour and a half.

Both these propositions, I think you will admit, sound promising until the sceptic intervenes by saying: "Ah, yes! That's all very well on a fine day, but what about bad weather? How are you going to keep your London-Paris service going, with safety and reliability, in the sort of conditions we meet with, often for days on end, during the winter?"

Operating an Airway in Bad Weather.

I realise we are now approaching the crux of the whole question. Firstly, in organising an aerial transport service, we must lay our plans on the basis of bad weather conditions. We must organise, in fact, for bad weather flying. A pilot on a fine day needs practically no organisation at all. He can leave London and fly to Paris, finding his way by map and compass and visual observations, and being almost completely independent of any assistance from the ground. But when there is cloud, mist, or fog, or when he is flying at night, his success in travelling to schedule, as a train does to its time table, must depend mainly on the patience and the perfection of the organisation of the airway. Here there is one very important fact which we, in the industry, must never lose sight of. It will be in the early days of commercial flying, when the public will be watching results with a critical eye, that no single detail of organisation, however small, must be omitted from the general scheme of safeguards.

It is always best, if one can, to bring a question like this to a practical issue; and so I propose to take a big passenger craft, of the type I have just shown you, and to see how weather conditions would affect the flight of such a machine. Fine weather, naturally, we rule out of the question; we do not legislate for that, because it represents a condition in which organisation is least required.

Now to combat bad weather. Here it is necessary to define what we mean by bad weather. Ordinarily, and on such a route as that between London and Paris, we mean high and gusty winds or heavy rains, or perhaps a combination of both. When we talk of bad weather, indeed, we usually mean a wet day or a windy day, or a day on which it is both wet and windy. How would such conditions affect a big machine such as I have described? The answer is that neither wind nor rain would have any detrimental effect at all on the flight of the machine. What I mean, when I say this, is that neither wind nor rain, nor both, would imperil in any way the safety of the machine, or of its passengers, or prevent its reaching its destination. Of course, in a high wind, if it is a head wind, the flight of a machine would be somewhat prolonged; or in rainy weather, when there are banks of low-lying cloud to be contended with, time might be lost in ascending to a higher altitude than would ordinarily be necessary. But the point is that neither wind nor rain, unless the former attains the velocity of a hurricane, will have the power to suspend the running of an air service, provided that it is being conducted with suitable multi-engines machines, and the ground organisation of the service is adequate.

Naturally there is the question of delay to be considered when a machine has to fly against a strong head wind. But even should it be so delayed, it would, in almost every case, still show a very marked saving of time over land and sea travel. Taking the big triplane I have described, which is capable of maintaining a speed of 100 miles an hour, this would mean that under favourable conditions, and reckoning the distance by airway at 250 miles, the journey between London and Paris would be made in two hours and a half. And even assuming a head wind as strong as 40 miles an hour, blowing directly against the machine during the whole course of its flight from London to Paris, the journey would still be made in four hours, instead of in about seven or eight by land or sea. One must not forget, either, that in the reverse direction, from Paris to London, a strong following wind might make it possible to shorten the normal journey by an hour or more; with the result that passengers might on occasion make their journey between the two cities in as short a time as an hour and a half or even less; in which case anyone making the return journey would occupy very little more time than would be entailed in the same journey under favourable weather conditions.

The point, however, is that neither wind nor rain—which are the two most common forms of bad weather—will have anything more than a partially adverse effect on the flight of such powerful machines as we are now able to build. When the wind attains the violence of a full gale, and the cross-Channel steamer services

have to be abandoned temporarily, we must naturally expect, at any rate for a time, that our aerial services may have to be abandoned also. There are indeed absolutely abnormal weather conditions in which any form of service must expect to suffer some temporary interruption. But it might be quite possible to fly to Paris on occasions when the Channel conditions make it not only extremely unpleasant but also dangerous to cross by water. I think it is a most encouraging fact that even within so short a space of years the aeroplane should have ceased altogether to be a fine weather machine, and should be capable of being navigated safely even in a violent wind.

Flying in Fog.

We come now to our real weather enemy—fog. Here, however, we should make quite certain how far fog is really a menace; and this brings out at once the fact that, assuming we have the organisation I shall describe, fog should not trouble us very much except at the moment of alighting after a flight. This is a great feature in favour of an airway as compared with a railway. A railway train, in fog, has to grope its way constantly through obscured air; it cannot, as can an aircraft, climb quickly through the fog-belt until it is above it, and then move ahead in perfectly clear air. On a foggy day, for instance, even if the fog should extend over a wide area on the London-Paris route, it would mean absolutely no delay at all in the actual travel of the machine once it had cleared the fog-belt after leaving its starting point. It must be remembered also that fog is generally low-lying, and that in a thousand feet or so, as a rule, a machine would be in clear air. And on a properly organised airway, with special fog regulations in force as to the inward and outward traffic at main aerodromes, there should be no risk of collision while a machine was climbing through the fog; and when it was above the fog flying would be perfectly normal. Nor would the pilot be embarrassed at all during the time he was climbing; I mean to say that his instruments would tell him all that he wanted to know as to the inclinations of his machine; while wireless and other signals would inform him whether his course ahead was clear.

It may be asked: "Doesn't he run a risk of losing his way, or of deviating from his course, if he flies for several hours without being able to see a landmark?" The answer is that he would not, provided he was aided by organisation. By sending up kite balloons along an aerial route, which will fly conspicuously day and night, above the fog-belt, and also by the aid of directional wireless, it now becomes perfectly feasible, even if a pilot has to fly for hours without seeing any landmark, to keep him with accuracy on any given course. I will now show you a slide illustrating the London-Paris airway under conditions of fog, and with a line of kite balloons riding above the fog-belt, thus acting as guides for the aircraft which are in transit between the two cities.

SLIDE FIVE (see end pages).

The chief risk lies in alighting on an aerodrome obscured by fog. Here the problem for an airway, as for a railway, is to illuminate the fog. What we must have is a system of illuminations which will throw light beams upward through the fog and which a pilot can see as soon as he passes down from clear air into the upper layers of the fog. The main question here, with rays projected from searchlights showing vertically upward, is one which is familiar to students of such problems—the difficulty being to get a ray which will penetrate through a fog and will not be dispersed and dissipated when it impinges on the thick masses of the fog. Assuming, however, that we have the best form of light available, it should be possible to indicate the contour of the aerodrome by means of half a dozen or more of these searchlight rays, each pointing vertically upward. Then a pilot, having flown above the fog until he reached the aerodrome on which he had to descend, and being able to locate its position by means of the guiding balloon riding above it, would descend slowly into the fog until he caught sight

of the searchlight rays. Round these he would then circle, reducing his altitude by degrees, and estimating his height above ground level by means of his instruments. Then, when he had got low enough, he would turn in between any two of the searchlights and make his descent somewhere in the middle of the aerodrome—a manœuvre he might accomplish quite safely, when he had become familiar with the general lie of the ground, without even having caught a glimpse of the actual surface on which he was alighting. It should be possible, also, for a kite balloon riding above the fog to have searchlights attached to a cable suspended from it, and shining vertically downward; these would help a pilot while he was passing through the upper layers of the fog, and before he caught sight of the searchlights shining vertically upward from the ground. My idea is, I think, suggested fairly clearly in the slide I will now show you.

SLIDE SIX (see end pages).

This whole question of fog is, as a matter of fact, a fairly simple one. We can send a machine up through fog, and we can guide it accurately when it is above the fog, and the only real problem which presents itself is to assist the pilot when, at the end of the journey, he requires to make a landing.

What I should like to represent very strongly is that on a well organised airway we should in some respects be in a better position to combat fog than is a railway or a ship at sea; and I do not believe that, except in extreme cases, an air service should be interrupted seriously by fog. It should be pointed out also that there is a possibility with an air service of doing something that is impossible with a railway, and that is to make a detour completely round any localised belt of fog. It might happen that whereas one aerodrome was shrouded in fog another only a few miles away would be in comparatively clear air; and in such a case it would be perfectly feasible to transfer traffic temporarily from one aerodrome to another. One might take as a simile the cross-Channel steamboat service; sometimes in very bad weather, when it is impossible for the boat from Dover to get into Calais harbour, she can, by running down the coast, safely make the harbour at Boulogne.

I have now dealt with wind, rain and fog; but there still remains snow. Should there be a heavy snowfall, traffic might certainly be suspended temporarily; but here again, having regard to what one may call the elasticity of an air service, there should be no difficulty about transferring the arrival and departure of machines to some neighbouring ground, where conditions were less adverse.

Now as to the question of organisation, on which so much will depend. This question, when one examines it carefully, is really simple. It involves in the first instance the linking up of all main and terminal aerodromes by means of a chain of emergency alighting grounds; by the creation, in fact, of a regular aerial way. The value of emergency alighting grounds may quite easily be exp'ained. Let us imagine a London-Paris air service being run without any such safeguard. One of the high-speed machines I have described, while on its way to Paris, and when between London and the coast, might have a sudden breakdown of its motor, with the result that the pilot would have to make a forced landing on the best spot he could see. He might alight safely, but this would be a question of luck. With such a fast machine as he would be flying, needing skill in alighting even on a smooth surface, the chance of getting down safely, without any damage, would be none too good. Even if he did alight safely he might do so in some place where it was difficult to reach him, and where delay might be caused in transferring the mail from his machine to another and sending it again on its way. It is possible, too, that time might elapse, after such an involuntary descent, before the pilot could get into touch with any aerodrome and describe where he had come down.

I do not wish to infer that aero-engines are very prone to break down; they are not. They are now attaining the reliability we expect from a good motor-car engine. But when we carry His Majesty's mails, or when we have the responsi-

bility of a passenger service, I think the argument is a sound one that we should neglect no safeguard, however small, which will ensure safety and reliability. It is certain that a system of alighting grounds would do this, and also something more.

The system advocated, which has the support of practical pilots, who realise what would be entailed in maintaining daily service by air, is that on such a route as London-Paris we should have an emergency landing ground every ten miles. If this were done, and if aircraft on the route flew always at a fair altitude, the system would ensure that at any moment, if his engine failed, and even if at the instant it did so he was exactly midway between two landing grounds, a pilot would always be able to reach one or other of them in a glide, and make a safe landing on a smooth and suitable surface.

SLIDE SEVEN (see end pages).

The slide I now show you illustrates quite simply the idea underlying this system. Here you see two emergency alighting grounds. Exactly midway between them is an aeroplane. This machine we calculate to have a gliding angle of one in six. That is to say, when its motor stops, and it has to use the force of gravity to maintain it in forward motion, it will move forward six feet for every foot it descends. When he is flying such a machine, therefore, a pilot has only to maintain a height of from 4,000 to 5,000 feet in order to be certain of reaching a landing ground, even if his motor stops when he is midway between two grounds. Should this happen, he might either glide straight on to the ground ahead, or turn and glide back to the one he had just passed. The direction of the wind would be the determining factor. As a matter of daily habit pilots would probably fly a little higher than was actually demanded by the gliding angle of their machines, because this would give them something in hand, in the way of altitude, when they had to make a forced descent. This might be useful to them when a side wind was blowing, and they had to glide down steeply, and perhaps a little into the wind, in order to get a landing point. Assuming there was a strong side wind blowing across the aerial route, then pilots would of course fly a little to windward of the chain of alighting grounds, and thus prevent any risk of being drifted away from them during a glide.

I have heard it argued that an emergency landing ground system, which would naturally entail expense, has now become almost unnecessary because of the reliability we can obtain even with machines driven by only one motor. It is also argued that it is not wise to tie an air service down to one fixed route like a railway. In doing so, I have heard it stated, one robs it of the superiority which it possesses over a land service; of its ability, that is to say, to do without a permanent way, and fly by any route on which weather conditions happen to be most favourable. Personally, I think there is much in favour of this argument. We certainly should not envisage an air service as passing always along one fixed line of country. If we did so, and when the time comes for meteorology to tell to us from day to day just those areas and altitudes where flying conditions are best, we should not be in a position to avail ourselves of such assistance, which will be of the utmost value. When, for example, regular flights are made from London with the Italian mail, I foresee that whereas on one night we shall fly direct from London via the Paris-Lyons route, on some other night, acting on meteorological advice, it may pay us to sweep out in the direction of the Bay of Biscay, and climb to some altitude at which we shall be aided by strong winds.

This, however, to my mind, is no argument for abandoning the principle that in the early days of commercial flying, and on main routes, we should have landing grounds disposed so that at any moment we are sure of making a safe descent. We must legislate not for the exceptional occasion but the general rule; and the general rule in commercial flying, when speed is everything, will—weather permitting—always be to go the shortest way. Therefore on the London-Paris route, to take a practical example, I think we shall find that traffic will, in the majority of cases, pass along a fixed and well-defined track.

I am not prepared to argue that we shall always want a ten-mile chain of landing grounds. Personally, I think we may not, but I agree heartily that we should have them to start with; and I am perfectly convinced that if we have them at all then they should be arranged carefully on a well-devised scheme. We, and other nations, should agree without delay to an international rule that on all the main routes through Europe there should be an alighting ground every ten miles, so that mail machines and passenger craft—not forgetting the aerial tourist—will always be within reach of an alighting point.

Here then is the basis of our organisation; the creation of a regular aerial way, and I will now show you a slide which gives a panorama view of the London-Paris route, as seen from above.

SLIDE EIGHT (see end pages).

Here you see a main aerodrome just outside London with a chain of alighting grounds at ten-mile intervals between it and the coast, and with the route continued on the other side of the Channel to Paris.

On the Channel crossing, and as to the possibility of a machine descending through engine failure while above the water, it should be mentioned that a pilot would, as he approached the coast, climb gradually until at the moment of passing out over the sea he was at a much higher altitude than when over land. It would be possible, when a pilot was flying a single-engined machine, with which there might be a risk of engine failure, to attain such a height on crossing the water that, even if the motor stopped suddenly exactly midway between the two coasts, he would be able to reach one side or the other in a glide. With multi-engined machines any risk of a descent while crossing the Channel would be almost non-existent; while even with a small high-speed mail machine, such as I have described, and which would have a single motor, the actual time occupied in the Channel crossing would be so short—in point of fact only a few minutes—that the risk of a descent in the water would be very small indeed.

As to the marking of aerodromes and landing grounds, a distinctive sign in the form of a white circle of chalk or whitewashed stones, which stands out against the background of the turf, has, during the war, been shown to be a good one. What we now require is a sign for landing grounds which can be adopted internationally, and which will be used on all the great traffic ways. It is desirable of course to have a simple sign, easily laid down and maintained, which a pilot can pick up readily even from a distance. It is suggested that each emergency landing ground should bear a number, displayed so that it can be seen from the air. It would be of advantage in a commercial service if the pilot who is obliged to make a compulsory descent could if necessary telephone to the nearest main aerodrome for a relief machine and simply say: "I am down on landing ground No. so-and-so." These numbered grounds would also tell the aerial tourist and traveller just where he was at any given time.

Value of Alighting Grounds in Touring.

A point we must not forget is that emergency grounds would be useful not only to a transport company, but to all other users of the aerial highway. Naval and military craft would use them whenever they required to do so. There would be garages on them in which machines could be housed; also mechanics in attendance, and a supply of fuel, together with the materials and plant necessary for carrying out repairs. Telephones I have already mentioned; they would be installed on every emergency ground. Such grounds would, in fact, serve the aerial traveller as do garages along a road the motorist. When you want to fly with friends from London to spend a week-end in the Midlands or the North, you will look up the landing ground nearest where your friends live, and alight there at the end of your journey, garaging your machine for the week-end just as you would a car. In aerial touring, in fact, these grounds will be of immense importance. They will give us an organisation which will appeal to the private

buyer of an aeroplane. Instead of his aeroplane being rather a white elephant to him in the sense that if he wished to visit any spot away from a main aerodrome he would not know where to house his machine, he would—if we had these ten-mile grounds—be sure always of being able to garage it securely, and of being able to get fuel and any other attention he might require. Then again they would save us from the risk of becoming unpopular with landowners and others by making involuntary descents on private ground. In war time everyone has been willing to take a lenient view of such invasions of their property, but now when private purchasers buy machines, and wish to use them as they would a motor-car, it will be very necessary for us to prevent any friction between those who use the air and those who remain on the ground.

In a compulsory descent, made suddenly on private land, we must be prepared to face the fact that damage might be done. During the war, in fact, a number of such cases have occurred; and it would be a thousand pities if, in the early days of commercial and pleasure flying, the public attitude showed any tendency to become hostile.

It is our desire in the aircraft industry to start commercial flying with the fewest possible restrictions so far as the law is concerned, because we foresee quite well how rules and regulations might retard progress. But when we ask for such freedom, and for confidence to be shown us, we on our part must recognise our serious duty towards the public. We must not only strain every nerve to carry safely the people who travel by air, but we must do everything in our power to prevent the use of the air being a peril or a nuisance to those who occupy the land over which our aerial routes will pass. Here, if one goes to the root of the question, there is nothing complex. The main risk is that the pilot of a single-engined machine may, unless he has a prepared landing ground within reach, have to alight suddenly on some spot where he may cause damage, or perhaps even injure some members of the public. This is a risk, however, which the chains of emergency grounds should render negligible.

Silencing Motors.

As to a point often raised—the noise an aircraft may make while flying—this is a matter we can now deal with effectually. There is no reason why a commercial or pleasure machine should not be so well silenced that it is practically inaudible from the ground. This question of silencing motors will have to be taken in hand not only in the interests of those who live near aerodromes or aerial ways, but also for the comfort of the occupants of a machine. The purchaser of an aerial Rolls-Royce will not care to fly for hours with unsilenced motors roaring away within a few feet of him; nor will the passengers in a London-Paris machine feel disposed, if they can help it, to endure a nerve-racking clatter all the time they are in the air. Nor is there any reason why they should; there should be no difficulty in fitting a satisfactory silencer, sufficiently light and efficient, and yet with no appreciable loss of power due to back pressure.

Another possible annoyance is when an aircraft flies low over private property, thus intruding upon a landowner's privacy, and perhaps causing him annoyance. When we have organised routes, however, and a pilot will not require, as is often the case now, to come down low to find out where he is, I do not think that the public will have any need for apprehension. Occasionally it may be necessary to fly low; but in the ordinary way a good pilot—and here I mean a man who flies considerately—ought to be able to make a journey from point to point without in the least endangering or annoying those who are on the ground. With the man who does not fly considerately, or who endangers the lives of others, we must deal firmly. He must have his flying certificate cancelled or suspended, and it must not be restored to him unless there are very good reasons for so doing. We have only to remember what an immense amount of harm a few "road hogs" did in the development of motoring to realise that this is a serious danger in dealing with which there must be no hesitation or half measures.

State-Provided Landing Grounds.

Now, however, though there are so many interesting questions I should like to discuss, I must remember there is a very definite time-limit to my lecture, and this leads me to a point which is of extreme importance. We have been discussing for some time past how, assuming the Government is ready to help the flying movement, this assistance from the authorities may be best applied. Here, without in the least closing the door to other proposals, I do suggest very definitely that State assistance would be of extreme value if the authorities took over, as a Government undertaking, the provision and maintenance of the chains of emergency landing grounds, the importance of which I have already described. If an aerial traveller had these routes provided for him by the State, in the same way that the State provides us with roads, this would be a form of very practical assistance. If we could have these chains of landing grounds provided, and suitably organised as soon as possible, the fact that they existed, and that they could be used by private flyers as well as by commercial machines, would, as I have suggested, help us enormously to develop aerial touring and pleasure flying, and generally to popularise the use of the air. In acquiring sites for these emergency grounds, and in framing a general policy as to their equipment and maintenance the Government would, it seems to me, be in a better position to cope with and to overcome any difficulties that may conceivably arise than would a private concern.

Furthermore, if we had State action in this matter, it would be all the easier for us to negotiate with other countries for an international and uniform system of aerial ways. A ten-mile system of landing grounds, or whatever other distance might be determined upon, could, for example, be established by agreement all over Europe. We could have the same ground signs, and the same signals at night, and such a uniform system, which could be relied on to be the same in all countries, would encourage very greatly the use of aeroplanes for international touring and private flying. If a man knew he could fly all over Europe along prepared aerial ways, and always have a landing ground with sheds and fuel supplies within easy reach of him should he wish to descend, then he would be much more likely to buy a machine than he would be if no such conveniences existed, and he ran the risk at any time of having to alight on unsuitable or privately-owned land.

The Rental of Grounds.

It should not be thought that to provide a Government system of landing grounds would be any great or costly undertaking from the ratepayers' point of view. Take, for example, the important route between London and Paris. On the ten-mile system one would require say twenty-five emergency grounds along this route. Each of them should, according to experience, be about sixty acres in extent; and I am told that, reckoning the present values of land, one should allow about £2 per acre for the annual rental of a ground. This would make £120 per annum for each, or a total of £3,000 for the rental of all the grounds along the London-Paris route. Of course the sea crossing in this case reduces the total number of grounds required, but still it can be seen what a relatively small item this is. As to the English side, it is encouraging to know that there are now so many military landing points already in existence that one would only have to fill in a few gaps, here and there, in order to obtain a complete ten-mile chain of grounds between London and the coast.

The main point I wish to make is simply this. Even assuming a liberal sum for the rental of emergency grounds, which we must remember would act everywhere as local air stations, and taking the number of grounds required on a main route like that between London and Paris, it will be seen that the sum of money involved is really quite small. Of course such grounds would need a staff. They would also require sheds and night-flying equipment. But when one contem-

plates an international scheme of such grounds, all arranged on a definite plan, then the total cost of such a system, which I have shown to be invaluable, would be relatively small.

Assuming the Government undertook this work, they would not of course be called on to maintain a chain of landing grounds without any revenue accruing from them. Aerial transport companies would pay annual fees for the right to use such grounds; while private tourists or travellers, when they alighted on one of them, would be called upon also to pay some specific fee. There would also be a scale of charges for housing machines, for supplying fuel, and also for executing repairs.

The grounds would be extremely useful also for R.A.F. machines, and might save many a bad landing. As flying develops, in fact, and the airways become more extensively used, I do not think there is any fear that the maintenance of a system of alighting grounds would be a burden on the Government. On the contrary, I think that as time goes on they would become self-supporting, and would eventually, when flying becomes the rule rather than the exception, prove a substantial source of revenue for the country.

The possession of organised aerial routes, radiating in all directions would, in addition to all the advantages I have described, be of immense value in night flying; and we must be prepared in course of time to run regular services by night as well as by day. Owing to the rates which the Post Office has to pay for the transport of some of its continental mails, I am looking forward to the time when we shall not only be able to carry such mails a great deal faster than by land and sea, but also to do so at competitive prices. One might take, as an example, the Italian mail. If we could carry this at night from London to Italy we should be able to save a clear day in the delivery of letters throughout Italy. When, as is now the case, we are in such close business touch with our gallant Ally, this should prove a very great boon indeed.

"Can an Air Service Pay?"

I think now that, in the time at my disposal, I have made out a good case to convince you, firstly that an air service will, if properly organised, be operated with safety; and secondly, that it will be conducted with reasonable regularity. This, therefore, brings me to my third and final point—"Can an air service be made to pay?"

In this regard, before going into actual statistics, I should like to make one or two preliminary observations. Any accountant knows, of course, that in the case of new undertakings where no practical experience has been gained, it is possible to make figures say very much what you like. Therefore, in connection with any speculative balance sheets, as to the running of aerial services, it is wise to examine these not necessarily with suspicion, but at any rate with a very critical eye. I have listened to, and also read, the statements on this subject which have been made by various gentlemen who are deeply interested in it; but I still feel that at present it is premature to hope to envisage, with any accuracy, what the future holds in store for us, financially, in regard to civil aerial transport. I have endeavoured, in the calculations which I have made, to err neither on the side of over-optimism nor on the side of over-pessimism, and have steered so far as I can a safe and reasonable middle course. It must always be remembered that we are entering upon an entirely uncharted and unexplored field of enterprise, full of pitfalls and difficulties which those who have studied the question for years are fully alive to.

The Problem of Depreciation.

A point in regard to which none of us have had sufficient experience is as to the rate of depreciation of the machines we shall be using for mail and passenger-carrying. It is well known, of course, that the more or less fragile type of

construction employed to-day will give place eventually to a very much more durable product, which will be far less susceptible to deterioration. But in any calculations made now, I think it very necessary to be on the safe side, and to reckon that the depreciation of existing type of craft will be very rapid.

Here, indeed, in this question of depreciation, lies the whole uncertainty in framing a profit and loss account for any air service which is to be operated fairly soon. As, however, I shall endeavour to show you that an air service *can* be run profitably, even to-day, I think you will agree that, when I set out to write off the total cost of a fleet of passenger machines over a period of only 12 months, I am under-rating rather than over-rating the possible life of such machines.

Uniformity of Loads.

The next point, and a very important one, is as to the uniformity of the loads to be carried by air. Here, I think, in aeronautics, we have an advantage over certain other means of transport as used to-day. If, on an air service, there is a heavy influx of passengers, mails, and parcels, it will be perfectly easy to duplicate or even triplicate the number of machines run. On the other hand, should the volume of traffic decrease suddenly for any reason, it will be quite a simple matter to use machines of lower capacity and so adapt our craft exactly to the demands that may be made upon us at any given moment. And it must be remembered here, that we shall not be dealing—at any rate for some time—with huge machines costing very large sums of money, but only with comparatively small craft. What I mean to say is that the cost of our traffic units will be trifling in comparison say with the cost of an Atlantic liner. The crews of our machines will also be small; it will not cost us so much if we hold machines in reserve as would be the case with a railway or steamship company. A reserve steamer, for example, standing by to meet any sudden influx of traffic, has not only to keep steam up but also to maintain a large crew. The fuel we shall consume will be in conformity with our loads. We shall always have as our advantage the elasticity and mobility of an air service. We shall always be able to run one or two machines instead of having one big machine waiting until it has accumulated its required load. In this way, on well patronised routes, it should be possible, and profitable, to run hourly or even half-hourly services. But of course we must always bear in mind that the extent of the public patronage must determine not only the general success of an airway, but also the rates that are charged for passengers, mails, and goods. If the public do not patronise the airways regularly, if the volume of traffic is small and intermittent, then rates must of necessity remain high. This is a matter which is in the hands of the public. If they show enterprise and initiative, and acquire quickly the habit of travelling by air, then we shall soon be able to carry them not only rapidly and safely, but also at extremely reasonable fares—always remembering that they must be prepared to pay for the great speeds, and the saving of time, which aerial travel will ensure.

I will now show you three slides, dealing with a passenger and express goods service between London and Paris, the type of machine used being that which I have already described, and which I showed you on my first slide.

SLIDE NINE.

Air Service London and Paris—distance 250 miles.
Twice daily each way—1,000 miles a day.
Two return trips per day equals 365,000 miles per annum.

A fleet of six machines fitted with 1,800 h.p. engines, each machine accommodating 24 passengers, crew of 5, and 500lbs. of express parcels.

Capital required £200,000

Annual profit, after writing off total cost of fleet at the end of the year, £50,000, which equals 25 per cent. on the capital.

SLIDE TEN.

Capital	£200,000	Six aeroplanes at £20,000 each	£120,000
		Plant and machinery at terminal aerodrome (for maintenance and repairs and shed accommodation)	30,000
		Working Capital	50,000
	£200,000		£200,000

SLIDE ELEVEN.

PROFIT AND LOSS ACCOUNT.—FIRST YEAR.

Fuel	£50,000	Income based on three-quarters of "load capacity"—	
Wages (crew)	7,000	18 passengers at a fare of £6 5s. 0d. (4 journeys per day)	£164,250
Repairs	25,000		
Parcels delivery	6,000		
Landing fees, etc.	5,000		
Insurance	10,000	375lbs. express parcels at 5s. per lb. (4 journeys per day)	136,875
Advertising	5,000		
Depreciation	120,000		
Management	23,125		
	£251,125		
PROFIT	50,000		
	£301,125		£301,125

I should like to say that in my opinion it will be most desirable, during this next spring and summer, to make a special effort to foster aerial touring and pleasure flying and not to rush into these daily commercial services until an organisation has been prepared and carefully perfected. It is no exaggeration to say that there are now many thousands of people, who, after becoming familiar during the past year or so with the sight of aeroplanes in flight, and having overcome in a sense their first strangeness at the idea of travelling by air, are now eager to experience for themselves the sensations of flying in an aeroplane. If we can satisfy this craving, if we can make it possible for large numbers of people to enjoy an aeroplane flight in comfort and safety, then we shall be accomplishing a very necessary and a very important piece of propaganda. It may be said, generally speaking, that the average man, though he would now be very glad of an opportunity to fly, only feels that he wants to make a pleasure trip—at any rate at first. He would prefer, probably, to make a first short trip in the neighbourhood of an aerodrome; and then subsequently to make a cross-country flight say of an hour's duration before embarking on an aerial journey from London to Paris. If, on his first pleasure flight, we can carry him in perfect safety, and with a comfort greater than he expected, then we may reckon that he will begin to think favourably of the aeroplane as a vehicle not only for pleasure but also for business transport. A man, for example, who has already made two or three pleasure flights will be much more prepared to come forward and become a passenger when his business is urgent than he would be if he had never flown at all. In the first instance his confidence would have been gained and he would have become familiar with the air, and with the comfort and safety which can now be assured. But if he had never flown before, and a journey of urgent importance suddenly became necessary, it is certain that he would hesitate before he decided to forsake the railway

in favour of the airway. In addition, then, to projects for regular daily services, it should be our aim during this spring and summer to take as many people as possible into the air. The ordinary public have read a great deal about flying, and during the war they have seen so many machines in flight that it has become almost a common spectacle; but still, even at the present time, the person who has flown is rare among his fellow-men, and to the vast bulk of the people the sensations of flying are as yet unknown. This is a state of affairs we must now remedy; and, apart from building large machines to accommodate the aerial tourist, we must encourage our prominent men to acquire suitable aeroplanes, and to use them when travelling as they would a car. If a dozen or two pioneers will do this—and Mr. Bonar Law, our late Chancellor of the Exchequer, has already shown us what an enormous convenience it is to use the aeroplane when on an urgent journey—the effect on the development of flying will be very marked indeed.

I will now show you a picture of a five-seated touring and pleasure-type aeroplane such as will appeal to those who are in the habit of being driven in their Rolls-Royce cars.

SLIDE TWELVE (see end pages).

This type of machine will either be privately owned or will be hired in the same way as are those motor-cars which are required for pleasure touring or business purposes. The machine depicted on the slide is essentially for those who wish to be driven by a paid pilot. You will see he is accommodated in a separate little cabin at the rear of the passengers, who have a full and uninterrupted view forward and on both sides of the machine, and are as far removed as possible from the engines, both of which are as efficiently silenced as are those of up-to-date motor-cars. The machine is equipped with two 270 h.p. Rolls-Royce motors, giving a comfortable flying speed of 80 to 100 miles an hour. It will be quite possible to fly this machine at a speed not exceeding 60 miles an hour; while by accelerating the motors to develop their full power a maximum speed of slightly over 100 miles an hour would be obtained. It is, therefore, safe to assume that under ordinarily adverse weather conditions a mean speed of 75 to 80 miles an hour could be maintained. Special attention has been paid to the design of the landing chassis of this machine in order to ensure safe alighting on any give-and-take aerodrome. You will notice that it is of the ordinary four-wheeled motor car type, and is furnished with brakes so as to bring the machine to a standstill in the shortest possible space when once it is desired to make a landing.

The cost of such a machine as this will, at first, be in the neighbourhood, probably, of £5,000 or £6,000; but this figure should be reduced considerably when materials and labour reach a more normal level, and also when the standardisation of such a type becomes possible.

Regarding the cost of running, here again, at the moment, we have to contend with the very inflated price of fuel; but I think it is safe to say that such a machine should be run at a cost for fuel of about 1s. a mile. Of course there are other expenses, such as the pilot's wages, the garaging of the machine, landing fees, and possibly the services of mechanics at terminal aerodromes to maintain the machine in flying condition. These would probably entail a cost of another 1s. a mile. It will therefore be seen that in the immediate future it will cost probably in the neighbourhood of 2s. per mile to fly such a machine, this figure covering all running costs. On this basis a trip to Paris, occupying say three hours, would cost £30, and as the machine would be carrying four passengers, this would work out at a cost of £7 10s. 0d. per passenger for the journey; a not unreasonable figure, considering the rapidity and luxury in which the journey would be accomplished, and remembering that the travellers would be in the position of using their own private vehicle, and would be able to start at any time they chose, irrespective of train and boat services.

For the pilot owner—the man who flies his own machine—I will now show

you a four-seated touring craft in which is eliminated any special seat for the pilot, and which could be operated at a lower cost than the five-seated machine I have just described.

SLIDE THIRTEEN (see end pages).

I do not propose to bore you with any other pictures of machines, as, of course, the types are practically unlimited, and can be designed to suit the most fastidious requirements.

In conclusion I should like to strike one note of warning. We in the industry know how undesirable it would be to permit hasty or ill-devised schemes for aerial transport. We know that safety and reliability are only to be secured by experience, coupled with the most perfect organisation that it is possible to obtain. To prevent aeronautics from being brought into disrepute, to ensure that only those who are well qualified for the task shall be allowed to carry mails and passengers by air in a public service, and to make certain that the craft which carry passengers are not only air-worthy in every respect, but are piloted also by men who are thoroughly proficient, it is obviously necessary that the Government, as represented in this case by the Air Ministry, should exercise a wise control, and should frame and enforce such regulations as will minimise the risk of accident, and help to bring aeronautics safely through the years just ahead of us which are fraught with so many problems and difficulties. Such Government control, exercised with discrimination, I am sure we all welcome, because it will be in the best interests of the great movement we have at heart. But at the same time—and here is my chief note of warning—we must always bear in mind, and guard against, the possible risk that our laws, though they may be excellent and comprehensive, may place us at a disadvantage when we are in competition, as we may be, with countries where the development of flying has been given a freer hand. There are certain specific aspects of this question which, if I had time, I should have liked to mention; but as it is I must content myself by putting forward the general and I think very important suggestion that, though we must obviously control flying, and study always the safety of the public, it will be most necessary for us, at the same time, to steer a safe middle course between too great a restriction and too great a liberty. In the latter case, to take that first, we may have the progress of the whole movement retarded by a number of accidents; while, in regard to the first, if we are too much regulated and controlled, we may, as I have suggested, find ourselves handicapped when we have to operate routes, or sell machines, in direct competition with rivals who are untrammelled by restrictions and who can pursue a bolder policy than is possible for us. If the Air Ministry, in its control of flying, can always bear in mind these two points of view, and preserve a nice balance between them, then I do not think we need have any fear as to the development of British aeronautics, even though we may have an uphill struggle during the next few years.

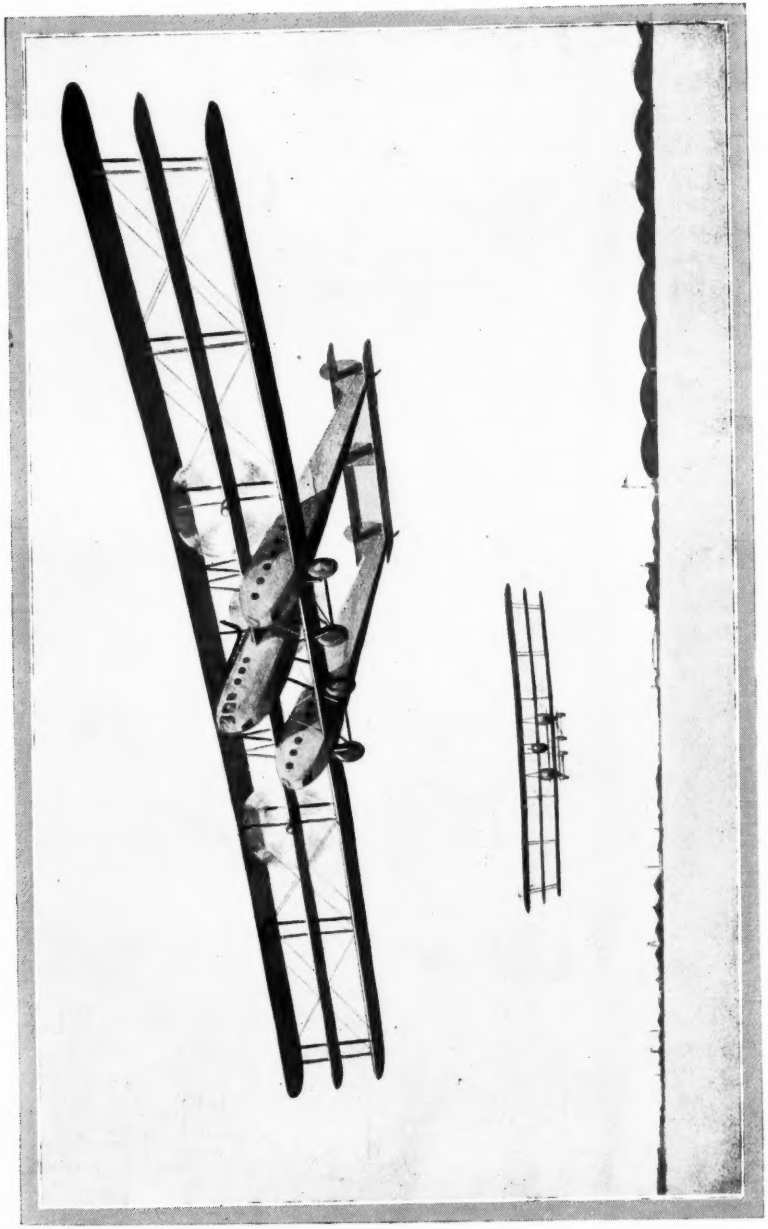
Finally, I should like to say this. The aircraft industry, now and in the future, must receive not only the financial support of the Government, but also the moral support and encouragement of the entire nation.

No cry for retrenchment, however desirable in other directions, must be allowed to retard the progress of aeronautics.

Money spent on aircraft is a form of national insurance—an insurance against our peril should some enemy, attacking us by air, endeavour to strike a blow so sudden and so paralysing that the whole nation, crippled and disorganised, would be compelled to sue for an immediate peace.

The same energy, determination, and grit which Britons everywhere have put into the titanic struggle that has just ended in a victory so glorious for our arms, that same spirit of unity both in purpose and in action which has animated the Allies, must now be devoted to securing, and then maintaining, the aerial strength and power on which the future safety of our Empire will most assuredly depend.

February, 1919. CLAUDE GRAHAME-WHITE.

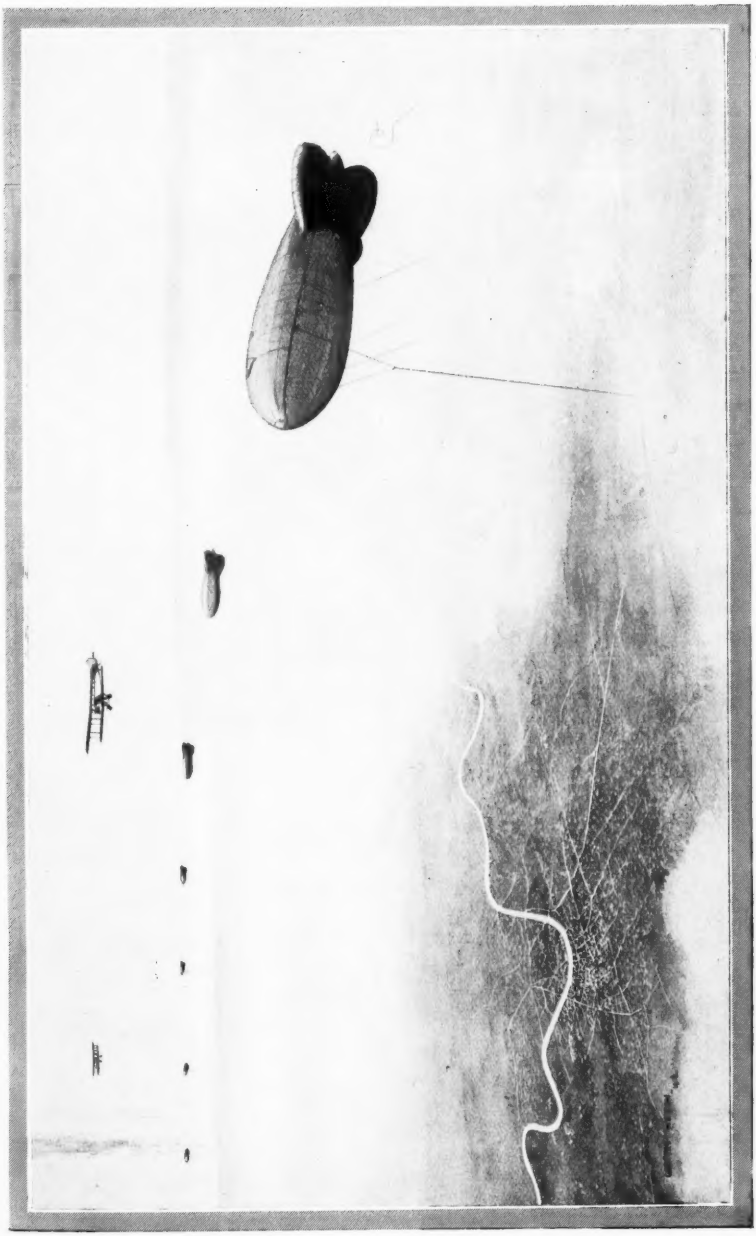


SLIDE ONE.—THE 24-SEATER PASSENGER MACHINE.

SLIDE TWO.—ENGINE ROOM OF 24-SEATER MACHINE.

SLIDE THREE.—PASSENGER NACELLE OF 24-SEATER MACHINE.

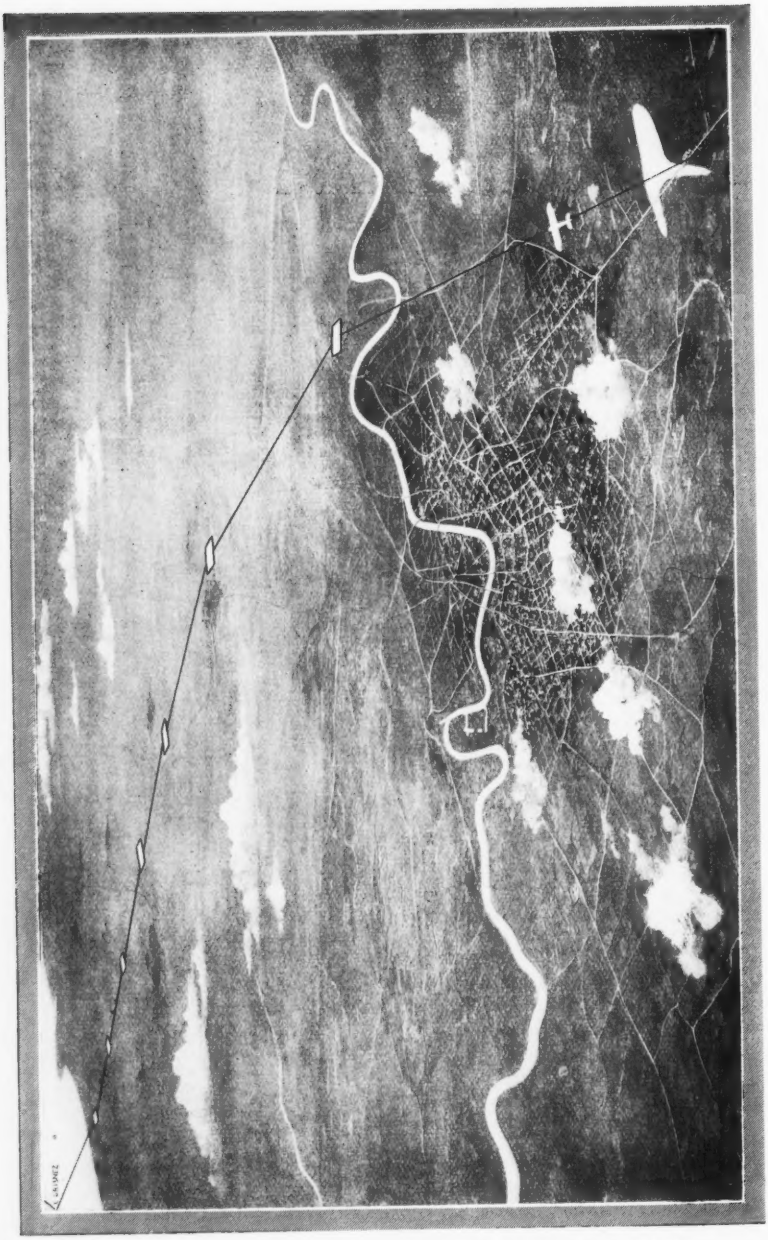
SLIDE FOUR.—THE EXPRESS AIR-MAIL MACHINE.



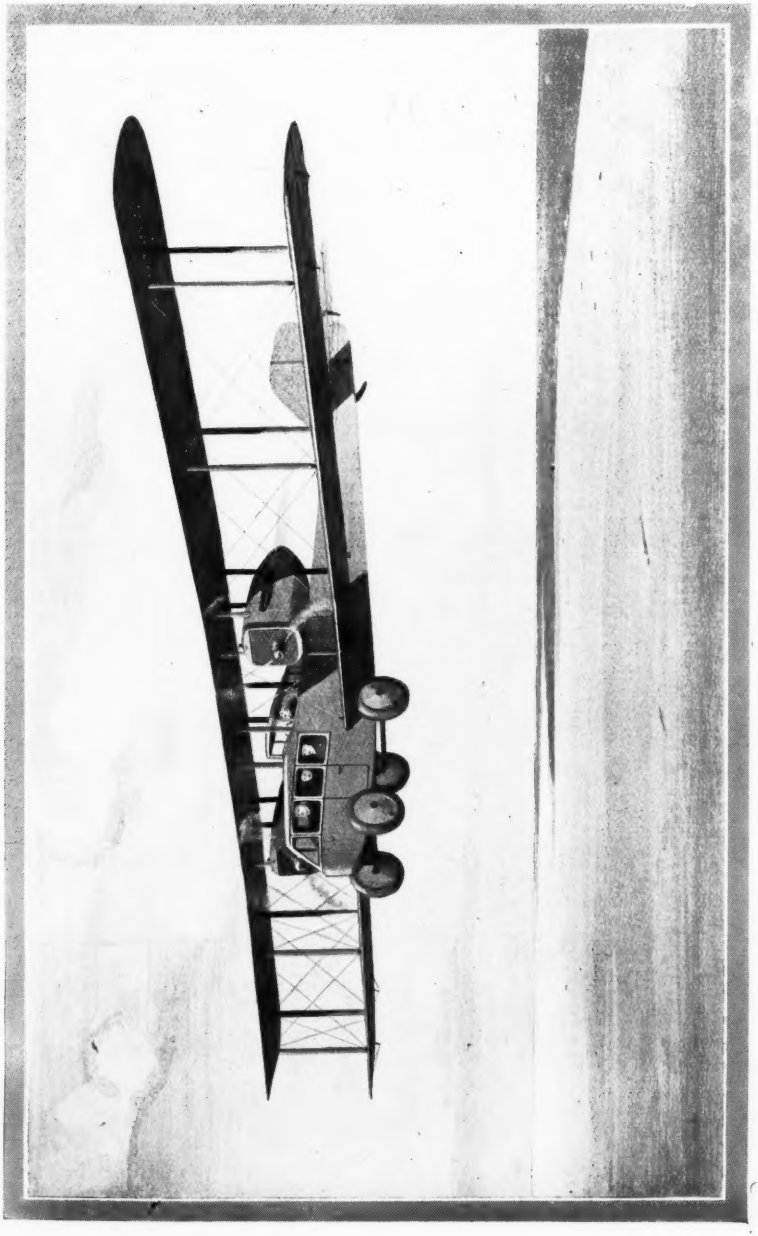
SLIDE FIVE.—LONDON-PARIS AIRWAY IN FOG.

SLIDE SIX.—FOG ILLUMINATION AT AN AERODROME.

SLIDE SEVEN.—IDEA UNDERLYING THE EMERGENCY LANDING GROUND SYSTEM.



SLIDE EIGHT.—PANORAMA OF LONDON-PARIS AIRWAY.



SLIDE TWELVE.—THE 5-SEATER TOURING AEROPLANE.

SLIDE THIRTEEN.—THE 4-SEATER TOURING AEROPLANE.

PROCEEDINGS.

EIGHTH MEETING, 54th SESSION.

The eighth meeting of the Session was held on Wednesday, February 12th, 1919, in the Theatre of the Royal Society of Arts, London, Lieutenant-Colonel T. R. Cave-Browne-Cave, C.B.E., R.A.F., presiding.

The CHAIRMAN said it was only custom that made it necessary for him to introduce the lecturer, Dr. Aston, as the majority of those present were familiar with his work. To those who did not know him, however, he might explain that previous to the war he was engaged on pure physics of the highest order. From the lecture it would be realised how extraordinarily well the pure scientist had been able to tackle the practical problem as soon as he was brought into contact with the difficulties of practical work and also into touch with men working on parallel lines.

Dr. F. W. ASTON, M.A., A.I.C., of the Royal Aircraft Establishment, then delivered his lecture.

DISCUSSION.

Dr. BARR said Dr. Aston drew the conclusion that only the light of short wave length—some 4,000 angstroms—caused deterioration of fabric. In one of the slides the rate of deterioration was plotted against the time of year, and on the same plate was plotted the total sunlight intensity. That pointed to a similarity between the action of light of various wave lengths. If the coincidence was so very good the obvious deduction would be that the deterioration was due to the total intensity of the sunlight, barring a few small deviations for about a fortnight in midsummer, and that it was not due merely to the intensity of the ultra-violet, because the ratio of short-waved radiation to total intensity must be different in summer from what it was in winter. Did the experiment with the mercury arc spectrum extend into the infra-red?

Dr. ASTON: It did extend into it, but the spectrum of the infra-red was all in about 1 m.m.

Dr. BARR said his argument with regard to that therefore broke down and he would not go on with it. The disparity between the effects of the direct light of the mercury arc and the light which fell on the plate in the spectrograph Dr. Aston attributed to the absorption by the air of the very active extreme ultra-violet. The ratio between the air paths in the two cases was about three to five, so that the total intensities would be reduced to about one-third in the spectrograph, which was not enough. Dr. Aston found the same disparity in his experiments at Greenwich, in which the sunlight contained no rays of very short wave length. He (Dr. Barr) thought the reason was probably that there was a very large loss of light in the spectrograph. Did Dr. Aston make any experiments as to the relative intensity of light which had gone some 75 cm. in the air and with the light which fell on the plate in the spectrograph? With regard to the data for the mercury arc spectrum in the thread testing experiments, the heights of the ordinates were taken from Ladenburg's figures for the intensities of certain lines and those ordinates had been spread out over the 2 m.m. in the spectrum. The values which should have been used were the integrals of the intensities for the small regions of the spectrum round those lines because the dispersions in Ladenburg's spectrum and in Dr. Aston's were insufficient to resolve them into really sharp

lines. By regarding them in that way the relative heights of the ordinates might seem different. The intensity of light in the region of the line at 4,060 was only about one-fourth of that at 3,600 angstroms, instead of about four-fifths, so that the absence of the deterioration effect was not so well proved. When he first thought about the method of measuring tautness of fabric by applying pressure he expected difficulties owing to the material being more extensible in one direction than in the other. He made apparatus to measure the tension before, during and after doping, with the edges fixed as they were on the plane, and he found a very pleasing result; although in some cases the initial tension in the warp was twice that in the weft before doping, after three coats of raftite had been applied the tension in both directions became the same, and it remained the same after the fourth and fifth coats were applied. Dr. Aston's method was quite absolute, and must give the right figure for the pressure as defined by the Engineering Standards Committee. The only modification possible was that the tautness as so defined might be made more accurately equal to the tension of the surface if, instead of having the constant pressure of 1 inch of water and measuring the curvature, the pressure could be varied so as to produce a constant curvature and measure the pressure. That would give the tension existing in the surface, even at very low tensions, the accuracy depending on the amount of curvature one decided to allow. Dr. Aston had referred to the instrument he (Dr. Barr) had devised for applying the air pressure to doped fabric. He did not claim that it was as accurate as Dr. Aston's, but he proposed it because it did not require airtight frames. The lecturer suggested that slipping might occur at the edges of an instrument of that sort, but the reverse was the case. With the G.A.C. tensionmeter the effect was to increase the slope in the same direction, and slipping was more likely in that case than with his (Dr. Barr's) instrument. He suggested that instead of putting the G.A.C. tensionmeter on with the plunger sticking out, the plunger should be lifted up until the rim touched the fabric. Were Dr. Aston's observations of humidity in relation to tautness made just as various humidities happened to occur, or was the humidity varied artificially? He (Dr. Barr) found he could make a curve almost any shape he liked with a humidity of over 80 per cent. It depended upon the time the specimen was in contact with the humidity and whether it was previously dryer or wetter than the atmosphere.

Mr. H. B. PRATT, who was asked by the Chairman to give particulars of the application of dope to airship covers, said they had never had outer covers long enough under observation to form a reliable conclusion. They had found that humidity caused perceptible effect. The change in the condition of the material followed immediately on the change of humidity. There was little lag between the change of humidity and the slackening of the fabric.

Mr. FLETCHER, dealing with the effect of humidity and tautness, said the frames were in a room in which the temperature was kept constant by electric heaters, the humidity was kept constant by sprays for an hour and a half before the measurements were taken, and the fabric was kept free from the actual particles of water from the humidifiers by a muslin screen. The 1½ hour periods were maintained with humidities of 50, 60, 70, 80, or 90, and in one case 96. The effect on linen and mercerised cotton was approximately the same. Until a high humidity was reached there was a constant tightening taking place, but with silk there was a slackening with increased humidity. Dr. Aston remarked that the tautness of the doped fabric was a function of the dope. In dry atmospheres, and up to 50 or 60 per cent. humidity, it was a function of the dope, but with humidities of 80 and 90 it was entirely a function of the fabric. Suppose three frames—fabric, doped fabric and film—were tested with a humidity of 90 per cent. and the records taken up to 24 hours, the fabric would remain fairly constant, the doped fabric would slacken (it would reach a depression of 9 m.m. per sq. ft.) and with the film it would be four times as great as that of the doped

fabric. Corrugations occurred because of the different lengths of the warp and the weft in the fabric. In high humidities, in his opinion, the tautness of the doped fabric was a feature of the fabric rather than of the dope. He did not know any aero-dynamical reason why tautness was made so much of. With an aluminium sheathing for the tip of the aeroplane wings, where the maximum lift occurred, no effect was found on the speed or lift. Theoretically the lift was obtained by the semi-vacuous air caused by the slip stream on the upper side of the plane. He believed that more than half the lift was obtained from that semi-vacuous area. It was a suck rather than a push. It was difficult to see why a tight fabric should have a great advantage over one that was not so tight. A method of measuring tautness could perhaps be devised by measuring the expansion of the dope film on exposure to the aqueous vapour (the saturated atmosphere) and a comparison could be got of various dopes, the effect of the fabric being eliminated.

The investigation of the tautness of doped fabrics is of such a complex nature that for practical purposes the undoubted great accuracy of measurement obtained by the spherometer appears of relatively small importance and that a simpler instrument taking substantially accurate readings would suffice.

On consideration of the many variables entering into the question of tautness, it will be obvious that the fact that the method is amenable to mathematical calculations does not greatly assist one in the interpretation of the results obtained by it.

Sufficient emphasis does not appear to have been laid on these many variables and it should be remembered that although the slackening of a doped fabric when exposed to a humid atmosphere is caused by the expansion of the dope film due to the absorption of aqueous vapour, this is by no means the only factor.

At humidities of 40 to 50% saturation the tautness of the doped fabric is entirely a feature of the dope, even the original tautness of the fabric before doping having little or no effect. At humidities of over 85% saturation, however, the tautness of the doped fabric is almost entirely a feature of the fabric, because one knows from experimental evidence that the expansion of a dope film under these conditions is very much greater than would be accounted for by the measurement of the depression of the doped fabric. The corrugations of doped fabric observed under humid conditions are admittedly due to the fabric and the increase of the maximum depression under humid conditions with continued weathering is explainable by the lengthening of the threads of the fabric due to the continued slackening and tautening lessening the undulations of the threads caused in the weave.

Between the humidities of say 50 to 85% the tautness of the doped fabric must therefore of necessity be a resultant of both the fabric and the dope.

The flexibility of the dope also plays a large part in tautness measurements quite apart from the tension or " state of strain " caused by the dope.

In view of these complexities and many others, and the great difficulty experienced in the interpretation of results, it would appear that much simpler tautness measurements would meet the case from a practical point of view.

Valuable comparative information on the effect of the dope could possibly be obtained by measuring the expansion of films with increasing humidity ; for instance, films made from nitrocellulose are by no means so sensitive to aqueous vapour as are those of acetocellulose, which may explain to some extent the beneficial results obtained by such coverings as V.114 and P.C.10.

The actual tautness measurement of a doped fabric can be readily taken by exerting a depressing force, usually by the application of a weight, on the centre of a known area.

The G.A.C. Instrument referred to in the report, is based on this principle, but it has great disadvantages, in that the whole weight of the machine rests on the

fabric, causing an error which cannot be accounted for, and also that the area measured is only that enclosed by the perimeter, which is very small.

An instrument of great simplicity has been in use by my firm for two years with excellent practical results. The instrument is based on the principle of a balance with a 10 to 1 beam so that the deflection of the long arm is magnified for a slight depression of the other.

The instrument is capable of adjustment so that the specified weight (400 grms.) can be made to rest on the surface of the fabric, and is compensated by a 40grm. weight in a scale pan suspended from the long arm.

By removing the 40 grm. weight the depression caused by the 400 grm. weight can be read off by means of a pointer attached to the long arm.

A simple adaptation on the same principle has been used for much larger frames, and might with advantage be employed in aircraft factories for aeroplane wings.

The theoretical considerations underlying the question of tautness are of intense interest and much valuable information has been, and will be, obtained on the lines indicated by Dr. Aston's paper, but it would appear that there is at present a great demand for some instrument such as the one described above, which will enable the manufacturer to obtain simple and yet reliable indications of the tautness of the constructed aeroplane wings.

I understand from Mr. Theodore Ward that he recently sent an article illustrating the above instrument to one of the aeronautical journals and it is due to appear shortly. I would suggest that before any form of tautometer is decided upon, the claims of this instrument should be considered.

Mr. WALLACE BARR said that he was not there to defend dopes containing tetrachlorethane, but he suggested that they should be given a fair chance and a decent burial.

Before the war dopes necessarily had to stand up for a considerable time and the doped planes generally lasted as long as the machines. Machines in those days were doped with dopes containing tetrachlorethane, and the machine was subjected to ordinary weather conditions, and when dopes were made on these lines with really good solvents, such as pure acetone, the results were apparently quite satisfactory.

For example, the machine on which Mr. F. S. Cody won the military trial in 1912 was doped with tetrachlorethane dope, which incidentally was put on top of all sorts of fabrics, and to the best of his recollection two planes were covered with pegamoid and the other planes with rubbered fabric, and he dreaded to think what the total weight per square yard came out at. This machine, owing to its size, had to spend a great deal of time in the open air, and he thinks it is still in existence at the British Museum or some other suitable resting place.

Another notable machine was the one flown up the Nile in 1914 by Mr. Frank McLean. This machine was flying for about six weeks and was never able to be covered over. It had to withstand the full force of the Egyptian sun, sand storms, and everything else, yet when it came back and the fabric was tested, it was found that it still passed the A.I.D. tests. He would like to point out that this machine received its very rigorous test in practically the same locality which the A.I.D. used for testing dopes during the war.

He submitted that this proved that dopes containing tetrachlorethane were satisfactory, provided one had suitable cellulose acetate and solvents to make them from, and it would be interesting to know what materials Dr. Aston had used in the tetrachlorethane dopes he had experimented with.

Dr. GOLDSMITH congratulated Dr. Aston on the brilliant results he had obtained. It had been overlooked both in England and France that the ultra-violet light was the chief cause of the loss of strength of the fabric. About 1910

in France Victor Henri applied to cotton fabric a pigment which had been sufficient to prevent ultra-violet from causing deterioration of rubber in balloons, but in a patent for a pigmented oil varnish for use on aeroplanes taken out in the same year there was no mention that the pigmented varnish would prolong the life of the fabric. In 1914 he (the speaker) made experiments in regard to the absorption by cellulose and cellulose esters; both in infra-red and ultra-violet light. In ultra-violet light they were transparent. His experiments supported those of Dr. Aston. The effect of the light was not directly on the cellulose qua cellulose, but on something else, such as oxygen, which was absorbed in the fibre. He remembered a legal action in which counsel for a laundry proprietor successfully defended a claim by a hotel proprietor for damage to curtains, by pleading that light caused the curtains to perish, and Dr. Aston's lecture would have fully armed him to plead his case. It would be hardly fair to put up the G.A.C. tensionmeter, designed by Mr. Twyman and himself, for competition as to accuracy against the stationary and more elegant instruments of Dr. Aston and Dr. Barr, for it was designed for inspectors and manufacturers who required a portable instrument to make a large number of readings in a short time. Mr. Twyman and he could adopt the suggestion to put a stop in, so that the plunger could be lowered to contact with the fabric after the ring of the instrument had been placed in contact. A proprietary pigmented dope was used extensively in 1916 and 1917 and it maintained tautness in an unusual degree. That was now confirmed by Dr. Ramsbottom, at Farnborough. The effect of dope in tautening aeroplanes was no doubt due to the lattice structure suggested by Dr. Aston, but it was difficult to understand how an agar gel containing 98 per cent. of water could be a solid.

Dr. RUDORF asked how long the frames were allowed to remain before the tautness was measured? Eventually they would get very near the point Dr. Barr mentioned. Were all the experiments made on linen fabric? The effect of humidity on cotton—especially mercerised cotton—was very small.

Captain G. S. WALPOLE said he thought those connected with the manufacture and use of aircraft would agree that the tetrachlorethane dope made here was not so good a commercial product as that made in Germany, although the Germans had to discontinue the use of it at the beginning of the war, which we also did, perhaps for the same reason. The German tetrachlorethane was more stable than ours. He was distressed to learn that Dr. Aston was going to desert dope and go back to the position he occupied before the war. There was nothing so romantic in the war as the application of Planck's hypothesis to the loss of strength of linen fabrics under solar radiation. It was one of the most beautiful applications of modern ultra-physics to a subject such as dope. In regard to the humidity curves it should be noted that the rapidity with which the water vapour got back into the dope film was greater after the dope had been weathered. The dope slackened more after weathering. In that he thought there was a clue to the structure of the dope, which became more permeable to water. He complimented Dr. Goldsmith on the thorough practical utility of his tensionmeter. The straight line relationship between the tension measured by the tensionmeter and the depression when measured with the spherometer after the pressure was diminished was very useful.

Dr. J. C. HUNSAKER, Navy Department, Washington, D.C.: It was a great pleasure to be present when Dr. Aston explained the recent work which he has been doing on doped fabrics, and I was especially pleased at his logical and direct method of attack. Now that war service is over the deterioration of airplanes is a much more serious matter than before. If commercial aviation is to be profitable, we must learn to build airplanes which will have at least a year's life without extensive overhaul. At the present time the wing covering is the most perishable feature of construction, and anything that can be accomplished towards preserving it will be of the greatest value.

The seaplanes of the United States Navy have always presented an unusually severe problem, so far as the wing covering goes, on account of their being used on salt water, and more especially on account of the intense sunlight that is met with on our southern stations—Florida, California and Panama. In 1915 the discovery that some form of pigmented covering would serve as a protection to the fabric was made almost accidentally. In stripping seaplanes at Pensacola, Florida, for re-covering, it was found that the fabric remained in good condition beneath an anchor which had been painted as a distinguishing mark with ordinary blue paint—the rest of the fabric was badly rotted, indicating that the blue paint acted as a preservative. At that time experimental work with balloon fabrics had shown the value of a lead chromate or other yellow dye as an anti-actinic protection. Experiments were then made by adding a yellow pigment to the dope with which seaplane wings were covered, and considerable improvement in life was realised. The colour, however, was unduly conspicuous, and was objected to by the pilots. Experiments to determine a low visibility colour led to the adoption of a very light slate colour, similar to that used on destroyers. This is now our standard colour.

In addition to actual deterioration of the fabric due to the actinic light, trouble was experienced with wing covering due to its slacking up. This slacking of the doped fabric seemed to occur after a prolonged exposure to high humidity, and took place long before there was any actual loss of strength in the fabric itself. Some of this slackness can be removed by taking the machines out of the hangar and exposing them to strong sunlight. Presumably this was a drying process only. At one station it was found that one or two additional coats of dope would restore some degree of tautness to the fabric. This procedure was not entirely satisfactory, however, because after a little time the dope itself began to crack, and then additional coats of dope could accomplish nothing.

Our present practice, which appears to give satisfactory anti-actinic protection, and at the same time to give some protection against the slacking of the dope film due to moisture, is to coat the wings after having doped them in the usual way with one or two coats of a good long oil varnish in which suitable pigment has been ground. Tung oil or Chinese wood oil makes a very satisfactory varnish, which is not affected by salt water, and appears to last at least a year.

The remaining difficulty is how to prevent this varnish flaking off; we find the varnish does not stick well to the ordinary acetate dope, but does stick to nitrate dope (Du Pont formula). It is our practice now to use one or two coats of nitrate dope on top of the acetate before the final colour varnish is applied.

It has been suggested that it would be an advantage to dye the fabric red or yellow; this would add no appreciable weight, and I would appreciate an expression of Dr. Aston's opinion as to the advantage to be expected. As we all know, it is the usual thing for fishermen to dye the sails of their boats, and I think this practice is almost universal, where very intense sunlight is the rule.

Dr. Aston's researches appear to prove clearly the effect of light upon the fabric itself. It would be valuable to know whether light has a similar effect upon the dope considered independently of the fabric. If such were the case, and we have some practical evidence to indicate that it is, it would not be entirely satisfactory to dye the fabric and to omit the pigmented outer covering.

In the testing of balloon fabrics we have attempted to arrange for an accelerated exposure test by subjecting the samples of fabric to ultra-violet light, but the attempt has been abandoned as the ultra-violet light tests were entirely misleading. It appears that the balloon fabric is seriously affected by the light, but the degree of such effect depends very largely upon the temperature and humidity. Is it not likely then that the action of light on doped airplane fabrics is also controlled by the presence of heat and humidity?

If heat is an important agent then both our slate colour and your P.C. 10 are undesirable on account of the dark shade. The idea suggests itself to borrow

from the experience with balloon fabric and use aluminium powder in the outer covering.

It seems clear to us that airplane dopes are affected by moisture and unless a new dope is developed which shall be unaffected, it is desirable to protect the dope by a truly watertight coating, such as the long oil varnish I mentioned above. P.C. 10 being a nitrate of cellulose, is no protection against the action of moisture, but merely serves as a vehicle to spread the pigment. I would like to ask Dr. Aston whether he can suggest any line of research which appears to him profitable, and which might lead to the development of a dope which shall be unaffected by moisture.

Blocks of wood coated with spar varnish, and similar blocks of wood coated with airplane dope have been given a prolonged soak in water and the increase in weight measured. The spar varnish is found much superior as a waterproofing agent.

I was interested to learn that the curvature of the doped fabric when deflected by pressure is the same along the warp and filling threads, indicating that the original strength and elasticity of the fabric had little to do with the final result. The next step would be to conclude that the dope film is carrying the load independently of the fabric. This seems difficult to believe because we have found in developing a cotton substitute for linen that very many apparently excellent fabrics would not shrink under dope treatment, and that it was necessary to develop a particular and special cloth in order to obtain the desired shrinkage.

Dr. ASTON, in replying, said he was unable to get any observations as regarded the ratios of short and long wave lengths in summer and winter, but he thought it was probably about the same in summer and winter. The amount of short wave light in the winter compared with the total light was not very different from what it was in the summer. At Greenwich he attempted to do a spectrum test on fibre, and the deterioration was very different from what it was in the case of a similar frame exposed to the sunlight at Farnborough at the same time, and for the same length of time. At Farnborough the deterioration was nearly three times as much, the difference being, he thought, entirely due to the fact that the short wave light was affected by the haze and smoke round Greenwich while the ordinary radiation was not affected seriously. He thought that proved that the deterioration was caused by the short wave light. He did not mean to express the opinion that the absorption of the air was the cause of the weakening of the light. The actual thing was the absorption in the spectrum. An enormous amount of light must be lost by deflection and other causes in the ordinary quartz spectrograph. The absorption by the air was not serious, except for extremely short waves, which did not come into the experiment. He was interested to hear that the results of the resolution of the arc lines differed from the results he took straight from Ladenburg's paper as to the intensity of the lines, but he did not think that it would make any difference in the actual results he obtained. He agreed that the surface taken on by doped fabric if the pressure were reduced was extremely spherical, and the tautness was taken by the dope. The tautness of the original fabric had little effect on the tautness of the doped fabric. The tautness seemed to be a function of the dope alone. If it were put on silk the final tautness was not much altered. In the figure showing the intensity of the sunlight in the spectrograph the ultra-violet portion of the sunlight was very small. In the test he made at Greenwich it was absolutely nil. The whole way through the spectrum it was evident that the infra-red long waves, though immense in amplitude, had no serious effect. The dangerous part was the small triangle from about 4,000 down to 2,050, where the sunlight gave out completely, being all absorbed by the air. With regard to the sloping of the G.A.C. tensionmeter and Dr. Barr's tensionmeter, he had investigated the frictional coefficient for dope and brass and worked out the forces that should occur, and they were of about the same order as the friction effect. That would

be unsatisfactory, even with the curvature Dr. Barr suggested. One could not rely upon no slipping, and therefore the method could not be accurate. One should put the tensionmeter first on the dope and then drop the plunger carefully. The humidity and tautness figures were got by quickly changing the humidity and then taking the tautness. Mr. Fletcher would be able to give details of the procedure.

The CHAIRMAN said he thought everyone would agree that what they had heard that evening showed a remarkable development. No doubt the scientists would disagree as to the details, but from a practical point of view a great improvement had been produced. They were told the plain doped fabric lost 1.2 per cent. of its strength per ordinary summer's day and the fabric doped according to the latest approved scheme with raftite and P.C. 10 lost 1 per cent. of its strength in three months. The fabric from modern German machines lost 53 per cent. of its strength, while the raftite and P.C. 10 lost 1 per cent. As the use of aircraft extended into the tropics, more particularly where the proper protection of the machines in sheds was difficult, ability to render the machine immune from the effects of sunlight and weathering would become still more important. Some of the instruments shown for measuring tautness would be of great value, both for aeroplanes and airship work. German officers had stated that the difference in the speed of a properly tensioned airship cover and one of inferior tautness was three or four miles an hour on a speed of 60 miles an hour. There were variations of pressure along the hull, and if the fabric were allowed to deform irregularly to those variations of pressure and to flap one could easily understand that the resistance would be materially increased. Possibly the same thing occurred in an aeroplane wing. He regretted that Dr. Aston would not be able to continue his work at Farnborough. Dr. Aston did not claim to be solely responsible for the progress which had been made, but he (the Chairman) thought he had played a very leading part in it. He moved that they accord Dr. Aston a vote of thanks, and he was certain that the applause with which that vote would be carried would have behind it far more enthusiasm than that of a formal acknowledgment.

Dr. ASTON, having acknowledged the vote of thanks, said he would like to express his gratitude to Dr. Lindeman, who worked out the theory from Planck's equation, and whose companionship had been of more value to him than anything else at the R.A.E.

Major-General R. M. RUCK (President of the Society) expressed the thanks of the Society to Dr. Aston for his valuable lecture, and also to those gentlemen who had taken part in the excellent discussion. He also wanted to extend a very cordial welcome to Commander Hunsaker, of the United States Navy, who was there that evening. He was a distinguished scientific representative of American aeronautics, and he was sure he (General Ruck) could say they would always be delighted to exchange views with their friends and allies of America. He was sorry to hear Commander Hunsaker was going back to the United States shortly, and he hoped that when he came here again he would take part in their discussions or perhaps give them a lecture.

He expressed the thanks of the Society to Colonel Cave for having so effectively taken the chair and given them the benefit of his experience. In a few weeks they hoped to see him playing the part of lecturer.

PROCEEDINGS.

NINTH MEETING, 54th SESSION.

The ninth meeting of the Session was held at the Central Hall, Westminster, on Wednesday, February 19th, 1919, General the Rt. Hon. J. E. B. Seely, C.B., C.M.G., D.S.O., M.P., presiding.

Major-General R. M. RUCK (President of the Royal Aëronautical Society), in introducing the Chairman, said he first wished to say a few words on behalf of the Society. Before the war it did its utmost to further the development of military aeronautics, and, he thought he might be allowed to say, with some success. Anyhow, it received the approval of the Air Council at the time. Recently, ever since civil aerial transport became a possibility, the Council of the Society had turned their attention to it, and they meant to do their utmost to further its interests and develop it. The lecture to be delivered that evening by Mr. Claude Grahame-White, on "Commercial and Pleasure Flying," might be considered as one of a series of very excellent lectures, of which they had already had several, on the subject. One was delivered by Lord Montagu, another by Mr. Holt Thomas, and a third, dealing more or less with the scientific aspects, was given by Colonel O'Gorman. He understood Mr. Grahame-White, who had consented to lecture that evening, was going to devote his attention chiefly to answering three questions which were almost invariably asked by the general public. He was sure, from what he had read of the lecture, that Mr. Grahame-White had given an immense amount of thought and spared no expense in tackling the problem, and that he would present it in a most interesting way. He might add that the Royal Aëronautical Society were devoting their attention at the present moment to forming branches of the Society in all the principal cities—or in many of them—and they hoped that lectures such as this would be delivered at the headquarters of those branches, with the object not only of developing the scientific side of aeronautics, but of furthering the cause of civil aviation, and bringing it home to the public. They also hoped they would be able to second the efforts of the Air Ministry in its great undertaking. The Society always received the support of the Army Council in their previous efforts as regarded military aviation, and they hoped and believed they would receive similar support from the Air Ministry. As an example, they had there General Seely, who had kindly consented to take the chair. General Seely was an old friend and a member of the Society, which he had helped a good deal before the war. He was a thorough believer in the future of this great movement, and he had the great advantage that he had had practical and personal experience. He was sure those present would desire him to express their wish that he would have every success in carrying out those very responsible duties which he had undertaken. He would now ask him to take the chair.

The CHAIRMAN said he was going to have the privilege of proposing a vote of thanks to Mr. Claude Grahame-White after the lecture. Therefore, he would say nothing now, and not very much afterwards, except in commendation of the lecturer if he did well—as he knew he would. He would say nothing except this: Earlier in the day many of them were present with His Majesty the King when the whole Empire paid a tribute of the undying gratitude they all owed to those dauntless spirits of the air who had laid down their lives in the recent war, and it was, perhaps, not inappropriate that on the same day they should meet together to consider how best all those sacrifices might be of use for the future of mankind. No better man could be found on that particular occasion than Mr. Grahame-White, who was one of those pioneers of whom our posterity, when they looked

back to the past, would say, "Well, these were the men who first dared to risk the passage of the air." It was not inappropriate that Mr. Grahame-White, who was the first to call upon a President by aeroplane, by coming down in the street, and who was the first to fly by night (though he thought he only intended to fly by day), and who risked his neck with really reckless valour in the early days of flying, should be now, after long study, addressing that, the most important scientific society dealing with aeronautics, on the future of commercial flying. When the lecturer invited him (the Chairman) to fly with him, he did not run away, though it was a very rough day and in the early days of flying, but now he was going to run away, because he knew the audience wanted to see the lecturer and the pictures on the screen, and he (the Chairman) would ask the President to accompany him to an obscure position down below, so that the lecturer might have it all to himself.

Mr. CLAUDE GRAHAME-WHITE then delivered his lecture.

At the conclusion of the lecture Mr. Grahame-White said prominent business men in London had already ordered some of the five-seater machines which he had described. Sir Alfred Butt had ordered one to enable him to witness matinee performances at some of his London theatres and go over to see the evening performances at some of his theatres in Paris. He might even buy one of the 24-seater machines and take over the whole company—it was a logical development which showed which way the wind blew.

The CHAIRMAN said he had a very pleasant duty to perform, and that was to tell Mr. Grahame-White how greatly they had enjoyed his lecture, and to move a hearty vote of thanks to him. He had showed them a picture of aerial travel in the future, and in the near future, and had said that what the Government ought to do was to secure safety, and also secure that aerial routes should be ready for the air travel that was coming. He accepted that as an obligation of the Government. (Applause.) They would do their utmost to provide safer routes. They had been taking steps already, and he hoped that by international or at any rate by inter-allied agreement they would have a common code of signals and aerodromes and landing places at regular intervals. They would have either the kite balloons that Mr. Grahame-White had suggested or some other means, but he thought that the kite balloons were ready to hand and would be the best to be sent up in time of fog. They must have illuminated aerodromes for descent at night. They would try to do all these things to secure safety of air travel, and he hoped that within a few weeks they would have come to an agreement with their Allies on the form that their activities should take. The future of commercial and pleasure flying would depend upon private enterprise, stimulated and encouraged further, if possible, by the Government, but depending mainly on the skill and energy of those pioneers of aviation of whom Mr. Grahame-White was by no means the least. The public would demand safety and for that reason the Government must insist upon the certification of airworthiness as they did for ships at sea. But flying was not so dangerous as many people thought. During the concluding period of the great war they flew 10,000 aeroplanes from this country to France in all weathers—sometimes in the most violent storms and even in mist and rain, and sometimes in fog—the greatest danger of all to the airman—and of that great number flown just over 98 per cent. were delivered without any accident or mishap of any kind. If one had been able to take some reasonable precautions, as one would do in times of peace, by having more carefully prepared routes or postponing departure for an hour or two when there was mist, the proportion of 98 per cent. would have been increased to 99 or more of perfectly safe travel from this country to France. From recent experience there appeared to be no reason why they should not make it safer still. In the service in connection with the Peace Conference, 300 flights had been made, and only one person (a pilot) had been hurt, fortunately not seriously, so they could

look forward to a time when people would not be afraid to use the air as a means of transit, and he hoped that they might look forward to its being used in long distance travel, in addition to the shorter distances to which the lecturer had referred. Wind was the enemy of the aeroplane for short distances, but might prove its friend for long distances, just as sailing ships were aided by the prevailing wind. He thought many here would live to see air travel carried on to a vast extent to the general good of mankind. Mr. Grahame-White had said polite things about the Air Ministry, and it was a remarkable feature of the present state of what he (the Chairman) might call air endeavour and air policy that all sides of it—the Air Ministry, the Royal Air Force, the Government, the constructor, the inventor and the flyer—were all one together and joined in one common spirit of comradeship to advance the science of flying, and he earnestly hoped and believed that might continue. He would like to express his thanks not only to Mr. Grahame-White, but to the Royal Aëronautical Society also and to General Ruck for bringing together great audiences like that to listen to interesting lectures, where they could make that common vow together that they would not quarrel about their differences, but use their united efforts to make air travel what it ought to be—a means of adding to the convenience, comfort, and happiness of mankind. He was sorry that Mr. Winston Churchill had at the last moment found it impossible to attend to second the vote of thanks. He would ask Colonel Cave-Browne-Cave to do so, and hoped he would not forget to mention the lighter-than-air machine with which he was closely identified, and which was a means of travel that might have great potentialities in the future.

Lieutenant-Colonel T. R. CAVE-BROWNE-CAVE said he had pleasure in seconding the vote of thanks to Mr. Grahame-White for his interesting lecture. It was to be regretted, however, that he had not gone further into the question of lighter-than-air craft. An airship had much more certain safety, being capable of sustaining itself in the air without the assistance of its machinery. The danger of fog was, with an airship, extremely small, and the dangers of a forced landing through engine failure practically disappeared. An airship was even untroubled by a combination of two evils—engine failure in a fog. Those who were familiar with the kind of defects from which aircraft suffered would know that the vast majority of these were of a type that could be got over in a few minutes if one could stop the machinery. Mr. Grahame-White rather insisted upon the necessity of landing grounds at intervals, say, of ten miles. That involved an enormous amount of preliminary preparation of the routes to be followed, but if the aircraft was not liable to be compelled to seek emergency landing grounds little preparation outside the terminal stations was required. The airship, even when broken down, could choose the time and place of landing, and could get safely down to ground which would be totally unsuitable for heavier-than-air craft. The announcements which had been made in the papers recently dealt largely with the rigid type of airship, and the impression conveyed to many people's minds by the descriptions of that type was that airships were very difficult to handle and were something rather in the distant future. He suggested that the smaller type of airship, the non-rigid type, which had been very largely developed in this country and with regard to which we are far ahead of any other nation, was the type most likely to play the most *immediate* part in future developments. The rigid airship was certainly good for long distance cruising and the work involving long ocean passages, but before that was practicable he thought the small airship might with great advantage be used for travel for comparatively short distance work and work over undeveloped countries, for which the aeroplane was unsuitable.

The vote of thanks to the lecturer was carried with acclamation.

Mr. GRAHAME-WHITE said he felt honoured, not only by the Royal Aëronautical Society, but also by the presence there as Chairman of so distinguished

a soldier and statesman as General Seely. He was proud (if he might say so) to have, in some small measure, initiated General Seely into the delights of aviation and also steered his imagination in the direction of the vast potentialities of commercial aeronautics generally. It was early in 1911, when a flight was no picnic, that General Seely visited Hendon and made a flight with him in a Gnome. He enjoyed the flight, and had ever since been most sympathetic with the development of British aeronautics. He (Mr. Grahame-White) felt that the years just ahead were fraught with many difficulties, and that just now they required all the sympathetic assistance and encouragement that General Seely and his chief, Mr. Winston Churchill, and the Government, and every member of the British public could give them, as it was only by the pressure of the public that the Government could be moved. He felt they could not place their future in better hands than those of Mr. Winston Churchill and General Seely. He thanked the audience for the kind way in which they had received his lecture.

Mr. H. White Smith moved a cordial vote of thanks to General Seely for presiding, and said General Seely had come to the very important position of Vice-President of the Air Council, after a distinguished career in the field, and he had undertaken a great responsibility at this stage in the development of aviation. He, with other members of the Society of Aircraft Constructors, had had two meetings with General Seely during the past week, and had been struck with the fair and open mind with which he had approached the questions brought before him and the kindness he had shown in dealing with them. He was sure it boded well for the future of aviation that General Seely was in charge of those questions. One was struck, after hearing Mr. Grahame-White's lecture, with the immensity of the questions to be dealt with, including the organisation of the routes, landing grounds, meteorological and wireless services, and many other details to make flying safe. They had had discussions with General Seely on the subject of air regulations, and had been able to appreciate how much he was doing to lessen restrictions and also to ensure safety. At that meeting of the Aëronautical Society—which was a scientific body—it was appropriate to mention the interest General Seely was showing in research. He was pressing forward aeronautical research with the object of making it one of the leading subjects for the Government to deal with. They knew General Seely would always maintain this country at the head of military aeronautics.

Mr. F. Handley Page, C.B.E., seconded the vote of thanks, which was carried, and acknowledged by General Seely.

ABSTRACTS.

Curtiss R-4-L Mailplane.

This machine, equipped with one Liberty engine, contains a mail compartment of between 33 and 35 cubic feet, with a carrying capacity of about 625 lbs. of mail. Its flying speed ranges from 100 to 135 m.p.h., and its landing speed is approximately 50 m.p.h. The wing span is 48 ft. ("Aviation," January 1, 1919.)

Standard Single-Seater Mailplane.

The machine weighs fully loaded 2,450 lbs., with overhang, and has a normal mail carrying capacity of 180 lbs. The wing loading is 7.12 lbs. per sq. ft., and the power loading 14.1 lbs. per h.p.

A detailed itemisation of the general characteristics follows:—

Main Dimensions.

Overall length	26 ft. 7 in.
Overall height	10 ft. 10 $^{3}/_{16}$ in.
Wing action employed	R.A.F. 15.
Area of upper wing	150.9 sq. ft.
Area of lower wing	138.1 sq. ft.
Total wing area, including ailerons	337 sq. ft.
Span upper wing	31 ft. 4 in.
Chord upper wing	6 ft.
Aspect ratio, upper wing	5.2 ft.
Span lower wing	31 ft. 4 in.
Chord lower wing	6 ft.
Aspect ratio, lower wing	5.2 ft.
Gap	5 ft. 6 in.
Stagger	5 ft.
Sweepback, in degrees	5 deg.
Dihedral	3 per cent.
Decalage, in degrees	0
Angle of lower wing chord to propeller axis	2½ deg.
Height of axis of propeller above ground with:—	
1. Machine resting on ground	6 ft.
2. Propeller axis in line of flight	5 ft.
Angle between line from base of wheel to C.G. with a vertical line when machine is horizontal	14 deg.
Angle between line joining wheel base and skid to a horizontal line	11 deg. 30 min.
Stabiliser setting to lower wing chord	0 deg.

Areas of Control System.

Aileron area, lower wing	24 sq. ft., unbalanced.
Aileron area, upper wing	24 sq. ft., unbalanced.
Aileron of stabiliser	23.7 sq. ft.
Area of elevators	22 sq. ft., unbalanced.
Area of fixed fin	4.6 sq. ft.
Area of rudder	10.1 sq. ft., unbalanced.

Summation of Weights.

Group.	Weight.	Percentage of gross weight.
Power plant...	778.5 lbs.	32.4
Fuel and oil...	390 ,,	16.2
Passengers and miscellaneous equipment ...	264.3 ,,	11.0
Mail	180 ,,	7.5
Body structure	288.1 ,,	12
Tail surfaces with bracing	75.5 ,,	3.2
Wing structure	324 ,,	13.5
Chassis	100 ,,	4.2
	2,400 ,,	100

Equipped with Overhang Section.

Area, main planes	382.4 sq. ft.
Area, upper plane with aileron	220.3 ,,
Area, lower plane with aileron	162.1 ,,
Area, upper aileron (2)	28 ,,
Area, lower aileron (2)	24 ,,

The machine is fitted with one Hispano-Suiza engine developing 170 h.p. at 1,700 r.p.m., climbs 5,300 ft. in 10 minutes, 10,000 in 24 minutes, and has a maximum speed near ground of 100 m.p.h. Its maximum endurance is 3 hours, or approximately 280 miles. ("Aviation," January 1, 1919.)

Curtiss Model K 12-Cylinder Engine.

This engine, of the fixed cylinder type, consists of twelve cylinders arranged in two groups of six at an angle of 60 deg. The bore is $4\frac{1}{2}$ in., stroke 6 in., and displacement 95.4 cu. in., or 1.56 litres per cylinder. In general it is of aluminium construction, with inserted steel sleeves; four interchangeable valves per cylinder, two intake and two exhaust; overhead camshafts driven by bevel gearing, and a single reduction by herring-bone gear to the propeller shaft.

The cylinder sleeves consist of high carbon steel hydraulic forgings, rough machined all over, and heat treated. The cylinder head proper is an aluminium casting, which, when assembled with six sleeves, forms a complete unit for one side of the engine. The casting contains internal threads to hold the cylinder sleeves together.

The pistons are cast in aluminium alloy and contain three rings per piston.

The connecting rods are of alloy steel drop forgings, heat treated, and finished all over.

The crankshaft is a 35-45 carbon chrome nickel steel drop forging—rough machined, heat treated, and finished machined. It is supported on five bearings, one at the front end, one between each group of four cylinders, and two at the rear end, one on each side of the crankshaft reduction gear. The main bearings are all $2\frac{1}{2}$ in. diameter and respectively 2—2—2—$2\frac{3}{4}$—$1\frac{5}{8}$ in. long starting from front. The crank-pins are $2\frac{1}{2}$ in. diameter, $2\frac{1}{8}$ in. long, and drilled out, as are the main bearings, $1\frac{7}{8}$ in. In order to balance the long cheeks between pins 1—2 and 5—6, steel counter-weights, carried on aluminium spacers, are attached to these arms.

Mounted above the crankshaft at a distance of eight inches is the propeller shaft supported on two journals—front $1\frac{3}{4}$ in., rear 4 in. long. The reduction gear rotates between these journals, and is fastened to a flange on the propeller shaft and driven by 7/16 alloy steel bolts.

The crankcase is an aluminium casting carrying the crankshaft, propeller shaft, and reduction gear; it extends up to form water jackets for the cylinders,

the cylinder heads and sleeves being bolted to a flange at the top of the crankcase. The upper part is bored out with six holes in each side, a recess in the bottom of each hole being fitted with a cork ring or gasket. The cylinder sleeves are inserted into these holes, and the flanges at the bottom of the sleeves compress the cork ring into the recess, and in so doing ensure a watertight joint between the water jacket and the crankcase proper. A gasket is placed between the flanges at the top of the crankcase and the lower surface of the cylinder head, the head being securely bolted to this flange, which completes the whole water system.

The bearings of the crankcase are bushed with phosphor bronze bushings, lined with tin babbitt.

The lower half of the crankcase is flanged and bolted to the upper crankcase at the centre line of crankshaft. It contains the oil pump, oil pump drive shaft, oil temperature regulator and oil reservoir. The reservoir is closed by a sheet of aluminium, held on a flange; this partition forms the oil sumps at either end, and prevents the oil from flooding the crankcase when the engine is in positions out of the normal.

The lubrication consists of a complete force feed system with auxiliary pumps to remove oil from above the oil pan deck. The pump unit is situated in the bottom of the lower crankcase, and is driven through a horizontal shaft from the vertical accessory shaft. A long account is given of the whole system.

At the top of the gear housing, and at an angle of 45° with the centre line are mounted the camshaft drive shafts. The camshafts are mounted on the top of the cylinder heads, one shaft over the exhaust valves and another over the intake.

The clear valve opening is 1⅝ in. diameter, while the seat is 1/16 in. wide. The valves seat directly in the steel cylinder head and are each held down by two concentric alloy steel coil springs.

The front end of the engine is mounted with an aluminium casting which contains the vertical shafts driving the various accessories, viz., the water pump, the gasoline pump, the magnetos, and the tachometer, and acts as a housing for many parts.

The cooling is by centrifugal pump coupled to the lower extension of the vertical shaft.

The ignition is by high tension magneto, two two-spark six-cylinder magnetos being used. These are driven through elastic block couplings through gearing from the vertical shaft.

The engine is equipped with two 52 mm. duplex Ball Aero carburettors. Each carburettor furnishes gas to three cylinders through a fan-shaped manifold. This is water-jacketed to assist in vaporising the gasoline. ("Aviation," January 1, 1919.)

Christmas "Bullet."

This machine, designed by Dr. Christmas, of the Cantilever Aero Co., New York City, is reported to have made a speed of 170 miles an hour with the engine at three-quarter throttle. It has a Liberty "Six" engine, rated at 185 h.p. at 1,400 r.p.m., and is stated to be the first successful machine having no wires or struts between the planes.

The upper wing has a span of 28 ft. and a chord of 5 ft. The lower plane is 12 ft. in span with a chord of 2½ ft. The wings are flexible, and during flight they bow, giving the appearance of birds' wings. The trailing edge is flexible also, and as the speed of the machine increases the wing flattens. In encountering shocks in the air and in combating severe winds, the flexibility of the wings makes the machine less subject to the racking effect felt in more rigid machines.

A photograph accompanies the article and shows the machine to be a single-seater tractor with a deep body, whose maximum depth is equal to the gap between the planes. There is a rectangular nose radiator and the airscrew is two-bladed.

The Cantilever Aero Company is stated to be making plans for the construction of a trans-Atlantic aeroplane of 180 ft. span, equipped with four 760 h.p. engines. A land model is to be used, and it is hoped that the machine will be the first to make the trip in a continuous flight. ("Aerial Age Weekly," December 30, 1918.)

Liberty Starter.

The Liberty starter is a four-cylinder radial two-cycle air motor and compressor, with a bore of $2\frac{1}{4}$ in. and a stroke of $2\frac{1}{4}$ in., with a 9 to 1 reduction gear for use as a starter. The valve construction is a semi-rotary of the Corliss type, having a universal joint action to the rocker shaft.

All the parts are idle except when brought into action as a pump with direct drive or as a starter with reduction gear. For the former service it compresses the air pressure in the tank and automatically disengages when the pressure reaches 230 lbs.

Illustrations give the elevation and sections showing the overall dimensions to be 12 in. square and 8 in. long. Its weight is only 30 lbs., which is said to be a low figure when the fact that it will start the largest engines in service has been taken into account. ("Aerial Age Weekly," December 30, 1918.)

Liberty Motor.

Through the courtesy of the Engine Production Division of the Bureau of Aircraft Production, Mr. Douglas Wardrop presents a series of excellent photographs and diagrammatic illustrations of the Liberty Twelve, including a number of the smaller engine parts. A complete list of general data giving the dimensions of the valves, pistons, and cylinders has been added, together with a detailed description of the cooling, oiling, ignition and carburettor systems, etc. ("Aerial Age Weekly," December 16 and 23, 1918.)

Hispano-Suiza Aviation Motor.

The Hispano motor has been developed in a large number of sizes and types for military aviation purposes. They are built with eight cylinders forming a 90° V in each case. This angular setting results in a uniform turning couple about the crankshaft, the power impulses being equally spaced from one another at 90°. The motor is unbalanced in a horizontal plane only, but the unbalancing is too small to affect the actual operation. The motors have been built in both direct and geared down types and operated at various speeds, as shown in the table.

Type.	Normal h.p.	Normal r.p.m.	Max. h.p.	Max. r.
150	150	1,450	200	2,000
180	180	1,540	250	2,240
200	200	1,870	210	2,200
220	220	1,970	238	2,200
400	400	1,870	500	2,240
450	450	1,970	476	2,200

The cylinders are machined from hollow steel forgings of 0.40 carbon steel, and weigh when rough about 40 lbs. for the smaller motors, the finished weight being about 11 lbs. The pistons are aluminium alloy sand castings thoroughly well ribbed to assist in cooling. The piston head is flat with an average thickness of 7 mm. The gudgeon pins are composed of chrome nickel steel, while the connecting rods of the fork type are made of the famous B.N.D. chrome nickel steel. The rods are 227 mm. centres, somewhat less that 2 piston strokes. Short connecting rods are the rule in aviation motors, since they enable the latter to be maintained compact and light, although the secondary unbalanced forces in the motor are thereby increased. At the top of the cylinders are placed the valves,

arranged in a single line parallel to the axis of the motor, a single camshaft operating all the valves and each group of cylinders. The crankcase is composed of aluminium and is cast in two halves split horizontally through the plane of the crankshaft axis, and the upper half is a very light shallow casting rendered possible by the use of short piston stroke and short connecting rods. To provide pressure on the fuel tanks, a low pressure pump is built into the camshaft housing cover, and is operated by one of the cams. The oil consumption varies according to the type of motor as indicated below.

Type.	Litres per hr.	Gals. per hr.
150 h.p. ...	2 ...	0.528
180 h.p. ...	3 ...	0.793
200 h.p. ...	4 ...	1.057
220 h.p. ...	5 ...	1.321

Ignition is provided by two spark plugs per cylinder, set to fire synchronously, the current is supplied and distributed by two independent high tension magnetos, cross-wired to the spark plugs so that should one unit be put out of operation the motor will continue to fire on all eight cylinders. The motor is provided with a single centrifugal water pump having a single inlet and two discharge pipes.

In contrast with the German method of pumping water through the top of the jackets only, it is led into the bottom of the aluminium jackets and out at the top. In order to obtain the best motor performance at each altitude, the carburettors are equipped with a hand-operated barometric control, by means of which the mixture can be maintained at the best proportions of air to fuel. Actually this is done by varying the pressure in the float chamber, and so reducing the effective head on the gasoline nozzle. ("Aerial Age Weekly," December 23, 1918.)

New American Diesel Motor.

There is a short illustrated note of the Hood type of motor, which in its latest form is a small single-cylinder of 2 h.p. The cylinder compression is not so high as the usual Diesel type, reaching only to 390-450 lbs. per sq. in., corresponding to a temperature of 400° F.

Very little information is given of this motor beyond stating that it can be run at speeds from 160 to 1,600 r.p.m., and has a brake efficiency of 25-30 per cent.; but it is of interest to note that an American firm has taken out a licence for its manufacture, but whether in a single or four-cylinder form is not stated. ("Automobilwelt-Flugwelt," December 1, 1918.)

Double-Piston Motors.

This article discusses several types of double-piston internal combustion engines, including the Junker aircraft motors. Reference is first made to the Gobron four-cylinder motor, built with the cylinders in pairs so arranged that the downward acting pair of pistons are attached to the same pin in opposite phase to the other pair and on opposite sides of them. The Sears, Evans, and Messpa designs are next described, the last being an engine driving on to two separate crankshafts. In the Junker tandem type the consecutive cylinders are arranged with a step of 90° in the crankshaft, so that the engine has no dead centre.

For flight motors of the double-piston type designed by the Junker firm an increased efficiency of 20 per cent. in fuel economy over the ordinary single-piston engine is claimed. (Diefeld, "Motor," November-December, 1918.)

Calculations on the Strength of Wing Spars.

In this contribution the wing spar is treated as a beam of uniform flexural rigidity supported at a number of intermediate points, laterally loaded uniformly

in each bay, and under end thrust, differing from bay to bay. The method follows that adopted by English mathematicians during the war in treating the same problem, although certain developments are missing in the German treatment. An extended form of the equation of three moments is obtained, one for each set of three consecutive supports. There are thus sufficient equations to determine the bending moments at each support on the assumption that the bending moments at the ends are known. These equations form a linear system whose coefficients are simple functions of the dimensions, properties and loading of the spar. It is shown that crippling will occur when the bending moments become infinite. This condition is easily written down as a determinant, from which the critical end thrust can be found. The analysis shows that when the spar is supported intermedially at a number of points the load to cause failure may be greater than the normal Euler's load. A number of special cases are worked out in detail. (H. Miller, " Zeitschrift für Flugtechnik und Motor-luftschiffahrt," September, 1918.)

Graphical Method to Determine Optimum Angles of Flight.

The author presupposes a diagram for the aerofoil given showing the variation of K, the resistance of coefficient, against K_y, the lift coefficient, with angles of attack.

The total resistance of the machine is then

$$W = W_x + W'_x = K_x F v^2 + kfv^2$$

where W_x = resistance of wing
W'_x = parasitic resistance.

If G is the total weight of the aeroplane,

$$G = KyFv^2$$

from which it follows that

$$W = \frac{K_x}{K_y} G + \frac{kfG}{FK_y}$$

For minimum resistance $\frac{dw}{dK_y} = 0$ and accordingly

$$K_y K'_x = K_x + kf/F.$$

The second term on the right hand side being practically constant, the two curves $K_y K'_x$ and $K_x + kf/F$ are easily constituted from the original diagram, their point of intersection determining the optimum angle.

In the same manner the h.p. required

$$L = vW = G \sqrt{\frac{G}{F}} \sqrt{\frac{1}{K_y}} \left(\frac{K_x}{K_y} + \frac{kf}{F} \cdot \frac{1}{K_y} \right)$$

The optimum position is now obtained from $dL/dK_y = 0$, that is,

$$K_y K'_x = \frac{3}{2} \left(K_x + \frac{kf}{F} \right)$$

practically the same curves as before, and once again the intersection gives the required position. (A. Fischer, " Zeitschrift für Flugtechnik und Motor-luftschiffahrt," July, 1918.)

Improved Climbing and Frictional Resistance.

This article states that when the wings of an aeroplane are being covered the fabric on the lower surface is sprinkled lightly with sand. Although the friction is thereby increased, the climbing power is considerably improved. This result is

associated with the production of innumerable small eddies all in close proximity to each other on the undersurface of the wing, forming a species of air cushion. A fact closely associated with this is the phenomenon that when a machine flies directly into a head wind it climbs better than when flying in still air with the same relative speed. The author considers that this effect is directly connected with the eddying air encountered by the machine.

Experiments are being conducted to test the effects of roughening different parts of the surface of propellers and streamline bodies, and these have so far given satisfactory results. They have shown that roughening the undersurface of the wing is favourable to the production of a cushion of supporting eddies. (Von Burberg, "Zeitschrift für Flugtechnik und Motor-luftschiffahrt," July, 1918.)

Aeroplane Photography.

This article deals with the commercial application of aeroplane photography to surveying purposes, such as mapping out high roads, railroads, estates, or any other topographic work. Not only is attention confined to map making, but also to contour surveys. An account is given of the methods of using aeroplanes for this work, and also of many practical details of a mechanical nature that occur in the automatic and controlling systems of the camera. The latter it is stated must be completely automatic and suspended in gimbals within the body of the machine so as to be free from air currents and capable of being maintained in a vertical position. The vertical position can be controlled by means of a gyroscope, mechanically undesirable, or by gravity with suitable air cushions to prevent oscillations. (A. Brock and L. J. R. Holst, "Aviation," January 1, 1919.)

Parachutes for Aeroplanes.

Mrs. Louis Bennet has offered a prize of $500 to the Aero Club of America for the development of a parachute which will be to aviators what the life preserver is to seamen. If the competition shows that efficient means are to hand for this purpose, and fool-proof methods of using it are decided upon, it is expected that carrying parachutes on aeroplanes will be made compulsory. The problems which have to be faced in this connection are set out as under.

(1) To determine a method of attachment for the parachute which can be operated for any attitude of the machine.

(2) Almost instantaneous attachment and action is necessary since the pilot may have merely a few seconds to think and act.

(3) The parachute must open quickly, must not drop too fast, nor oscillate too much in descending. The average parachute opens after a drop of about 120 ft., and then descends at a speed of, approximately, 20 ft. per second.

(4) Safety is not to be found in weight, which itself is an aerodynamic disadvantage.

A parachute of Japanese silk about 18 ft. in diameter capable of sustaining a man weighing 150 lbs. will not weigh more than 15 lbs. Large parachutes tend to take up oscillations and side-slip badly, while, on the other hand, if the parachute be too small it will descend too rapidly.

Pioneers like Baldwin and Stevens contend that control can be exercised over the direction of the fall by pulling the attachment ropes, thus forming a type of sail.

By pulling the ropes on two sides simultaneously, and thus decreasing the span, the speed of drop may be increased, and adverse air currents avoided. The nature of the harness connecting the pilot to the parachute is exceedingly important, in order that he may detach himself immediately upon touching the ground to avoid injury by dragging, in the event of there being a strong wind. It is anticipated that success along these lines will ensure the use of parachutes in dropping mails and packages from aircraft, and thus avoid landing. It is well

known that the Allies used parachutes during their latest advance to supply the most forward troops with ammunition. ("Aerial Age Weekly," January 6, 1919.)

Aerial Expedition to Explore Arctic Regions.

The Aero Club of America, of which Rear-Admiral Robert E. Peary is a member, has decided to back Capt. Robert A. Bartlett, the famous explorer, in equipping and sending to the Polar regions an expedition which will have as its aim the stupendous task of exploring and surveying the unknown Polar regions as well as exploring the depths of the Polar basin and the upper air of the Arctic regions.

It is hoped that the expedition will leave the United States in June, 1919, to take advantage of the period of comparatively warm weather which exists in the Arctic regions for six weeks of the summer, in July and August, when the temperature seldom falls below 60° F.

The plans are to have a ship to go to Etah, about 600 miles from the North Pole, in June, carrying a large seaplane or land machine for the flight over the Pole, as well as several smaller machines for scouting flights. At Etah a base would be established, and, while waiting for the ice to break up farther north to permit the ship to go as far as Cape Columbia, the small seaplanes would fly to Cape Columbia and establish a base there for the large plane which would fly from there over the Pole to Cape Chelyuskin on the Siberian side, and for exploration over longer distances.

It is hoped that results of inestimable value to science will be obtained from the expedition. Exploration which by the old methods would take about 200 years to do, it will now be possible to accomplish in about twenty years. At the present time only one-seventh of the earth's surface has been accurately mapped, two-thirds have been mapped from rough sketches only, and the remainder has not been surveyed at all.

There are hopes that discoveries of valuable minerals may be made and turned to account. It is known that mica and other minerals in great demand are to be found in the sub-Arctic regions, but to what extent cannot be said without further exploration. ("Aerial Age Weekly," December 30, 1918.)

Portable Airship Sheds.

The sheds described are made on the "Ermus" system, which is the subject of a German patent. The author points out the difficulties of housing an airship in a fixed shed, of which the opening may be in the worst possible aspect for a given condition of wind. He also criticises the rotary type of shed on the score of great initial cost. The new system permits of easy removal of the entire shed to another site, or to construct it upon the same site again with its axial line in a different direction. The skeleton framework consists of duplicate parts each comprising a lattice girder, to the centre of which is pivoted a strut of suitable length. Suitable foundation blocks of concrete are laid, each one having a suitable socket to receive the pin end of the articulated framework. Assuming the lattice girder with its strut folded together is lying upon the ground with the pin end of the strut in its proper position, then the extreme end of the girder, which is provided with a roller, is moved inwards, and when the strut is vertical the girder forms the roof principal at an angle of 45° to the horizontal. With the corresponding opposite principal in position, it forms a ridge roof, completing with the ground surface a triangular cross section. In order to permit of easy alteration to a different direction of its axis, say to any one of eight different points of the compass, it is sufficient to put in the requisite number of concrete foundation blocks with their suitable sockets. ("Deutsche Bauzeitung Supplement," December 4, 1918.)

Retractable Aeroplane Chassis.

An advertisement by the Martin Aeroplane Company shows an under-carriage which may be drawn up when in flight so as to be almost completely enclosed in the body of the aeroplane. From the figure accompanying the advertisement the under-carriage is seen to be in general appearance of the simple "vee" type. In an extract from a report by Mr. L. V. Kerber on one of the latest U.S. Army aeroplane designs of machine with retractable chassis the following particulars are given:—

At 100 miles per hour:—

Total resistance of extended chassis	59.6	Units not stated.
Total resistance of retracted chassis	11.0	
By retracting the chassis the total resistance is decreased 48.6/488.6	10 per cent.	
By retracting the chassis the maximum horizontal velocity is increased 145/137 — 1	6 ,,	

("Aerial Age Weekly," January 13, 1919.)

Instability of American Aeroplanes.

Investigations have been made at the Massachusetts Institute of Technology, Boston, on the dynamical stability of American aeroplanes, together with wind tunnel experiments in aerodynamics. The article is intended to summarise the reports of the investigations, omitting names of manufacturers, who, it is anticipated, will take advantage of the defects reported and remedies offered. ("Scientific American," February 8, 1919.)

Theory of Sprung Tail Skids on Aeroplanes.

It is claimed at the outset that attaching springs to the tail skid of an aeroplane is more important than it is usually considered. The skid is attached to the fuselage by means of a pin joint at a point near its centre and the upper end connected with the body by a spring. The oscillations set up when the lower end of the skid comes into contact with the ground on landing are examined from a theoretical point of view. It is supposed for simplicity that the landing wheels are rigidly attached to the ground, the aeroplane being free to move about the axle.

Let O be the point of intersection of the axle and the plane of symmetry, S the C.G., A a point on the fuselage vertically above the lower end of the skid. Also:—

$r = OS$.
r_s = the horizontal distance from O to A.
ϕ = the inclination of OS to the horizontal.
P = the reaction between the skid and the ground.
T = the moment of inertia of the machine about the axle of A.
G = the weight of the machine.

H and H' are the distances during oscillations above and below A_0. Suffixes 0 and 1 are used to denote the values of the quantities when the machine is in its *zero position* (*i.e.*, when the skid just touches the ground, but does not bear the weight of the machine) and in its position of equilibrium respectively.

The equation of motion about the axle is

$$Gr\cos\phi - Pr_s = -T\frac{d^2\phi}{dt^2}$$

Consider the first oscillation between the zero position and the lowest point reached by A.

If $x = \phi_0 - \phi$ and K a constant depending on the spring,

$$P = P_0 + Kr_s x,$$

and it is found on integrating the equation of motion that

$$x/x_1 = 1 + C \sin \alpha (t + t_0)$$

where

$$\alpha = \sqrt{\frac{Gr \cos \phi_0 - P_0 rs}{Tx_1}}$$

and

$$C = \sqrt{1 + \frac{2Gh}{x_1 (G_r \cos \phi_0 - P_0 r_s)}}$$

where h is the vertical displacement of S corresponding to a rotation x.

These equations give the maximum value of x, and hence

$$P_{max} = P_1 + (P_1 - P_0) C.$$

Now $Gh = P_1 H$ approximately, and since the work done by gravity from zero to equilibrium positions is equal to the work done by the spring for the same motion.

$$G_r \cos \phi_0 x_1 = \frac{P_1 + P_0}{2} H'_1, \text{ also } r_s x_1 = H'_1.$$

After substitution, the final expressions for P_{max} are obtained, viz. :—

$$P_{max} = P_1 + \sqrt{(P_1 - P_0)^2 + 4P_1 Hk}$$

so that the maximum value of P that is likely to occur can be found if P_1, P_0, H, and K be known. In particular, if $P_0 = O$ and $H = o$, *i.e.*, if there be no previous tension in the spring and the tail of the machine drops only from the zero position,

$$P_{max} = 2P_1.$$

The equation loses its meaning, of course, if the tail of the machine cannot fall through a distance H_{max} without touching the ground.

Now, substitute $P_0 = P_{max} - KH'_{max}$ in the above equation for P_{max} and solve for H, then

$$H = \frac{2H'_{max} (P_{max} - P_1) - kH'^2_{max}}{4P_1}$$

H_{max} will, of course, have to lie between limits defined in the design of the machine.

The article includes the solution of a few numerical examples where also the length of the skid is considered, and concludes with a remark on the friction between the skid and the ground. ("Oesterreichische Flug-Zeitschrift," December, 1918.)

Liberty Aeronautic Fuel.

The Liberty fuel is the outcome of research made in the United States with the object of developing a method of producing an artificial gasoline substitute. The article gives the results of tests made on the fuel at the Bureau of Standards to determine (*a*) those physical characteristics of the fuel which have bearing on its use in aeroplane engines; (*b*) the comparative performance of engines when using the Liberty fuel and aviation gasoline. The specifications referring to the manufacture of the Liberty fuel were not communicated to the Bureau of Standards, but it is understood that they are in the possession of the General Engineering Depot of the War Department.

The physical characteristics which were determined were (1) the total (high) and net (low) heating valves, (2) the specific gravities, (3) the distillation temperature characteristics. In addition a cooling test was made which showed that a considerable amount of crystallisation took place when the Liberty fuel was cooled to — 10° C. (+14° F.).

The comparative engine tests were made with a 150 h.p., type A, Hispano-Suiza engine with compression ratio 5.3. The results of the tests indicate that Liberty fuel compared with a gasoline, fulfilling the export specification for aviation gasoline, will develop about 3 per cent. greater horse-power when consuming 10 per cent. greater weight of fuel per horse-power hour. The thermal efficiency of the engine when using Liberty fuel is, however, about 2 per cent. greater than it is when using the export grade of gasoline. The sparking plugs used in the runs on Liberty fuel showed a slightly greater carbon deposit than the plugs used in the run with export gasoline.

A series of runs was made to determine if the use of Liberty fuel would dilute the lubricating oil more than standard export gasoline, but the results of these tests are not yet available. ("Aviation," January 15, 1919.)

Climb Meter.

A short note on a climb meter developed by B. Russell Shaw is given in "Aviation" (New York), January 15, 1919, accompanied by a sketch of the instrument, but without an explanation of its governing principle. The instrument consists of a small streamline tank mounted on the under side of the aeroplane body and connected by tubing to a glass tube mounted on the dashboard and containing liquid, variation of level of which indicates climb. The instrument registers zero within five seconds after a level flight is started at any altitude, and this reading is not affected by opening or closing the throttle of the engine. ("Aviation," January 15, 1919.)

Use of Aeroplanes in Forest Patrol Work.

Of the total area of the United States approximately 24 per cent. is forested. Statistics secured during the past three years (1915-1917 inclusive) indicate that the average annual damage caused by forest fires amounts to approximately ten million dollars, and that there are upward of 28,000 forest fires annually in the United States.

The chief object of forest patrol work is protection against fire. For this purpose the present method of detecting fires is by means of a system of well selected look-out peaks. The writer, Henry S. Glaves, Chief of the U.S.A. Forest Service, is of opinion—although no experiments have as yet actually been carried out—that the method of detection of fires could be greatly improved by the use of aeroplanes. Several disadvantages of the present method are given and the advantages of aircraft for the purpose are brought forward. As a means of prompt detection of fires in rolling or flat country it is doubtful if aircraft patrol could be excelled, and it is probable that by adopting aircraft patrol the numbers of men required could be reduced.

Besides their use for fire detection, aircraft would be very useful for scouting on large fires. It is the duty of a fire scout to determine each day how the fire is progressing in order that it may be fought to the best advantage, and in country where getting about from one place to another is difficult the use of aircraft would be especially advantageous.

It is suggested that aeroplanes might be employed for the speedy transportation of fire fighters from point to point, and, further, that aeroplanes of the bombing type might even be of use in fighting fires by the dropping of fire-extinguishing bombs. ("Aviation," January 15, 1919.)

The Farman "Aerobus."

Some particulars are given of this new aeroplane, which is apparently to make regular trips between Paris and London. On trial flights it carried on each trip 12 to 14 persons. This machine is a transformation of the Goliath type F60, which was designed as a bombing plane.

The characteristics of the new machine are:—

Span	28	m.
Bearing surface	168	m.²
Weight, empty	2,000	kg.
Useful weight	2,000	,,
Weight of fuel	520	,,
Weight, ready for flight	4,520	,,

It is engined by two Salmon Z. motors developing 500 h.p. in all. The speed for "commercial" purposes is 160 km. per hour.

The machine can rise in four minutes to 500 metres and in ten minutes to 1,000 metres. It should be possible to attain still higher altitudes, as it has reached 2,000 metres in twenty-five minutes carrying 3,000 kg.

The Farman aerobus, which leaves the ground in ten seconds over a distance of less than 50 metres, can land smoothly, when travelling at 60 km. per hour, and in a few minutes.

The machine is properly equipped inside for the convenience and comfort of the passengers. ("La Nature," February 22, 1919.)

Halberstadt Biplane C.L. II.

The first model of this machine appeared at the beginning of 1918. The type has been used for all purposes—fighting, reconnaissance and bombardment.

The principal dimensions, loading, etc., are as follow:—

Span of upper wing, 35 ft. 4 in., lower 34 ft. 10 in.; chord of wings, upper 5 ft. 2½ in., lower 4 ft. 3½ in.; gap about 4 ft. 3 in.; stagger, 2 ft. 2 in. positive. Total length, 24 ft.; lifting surface, 323 sq. ft.; total weight, 2,540 lbs. The engine is a 160 h.p. new model Mercédès.

The two planes are nearly equal, and staggered positively; the upper wings are swept back a little, and the lower have a dihedral of 1½°. The structure of the wings is entirely of wood, with the exception of the balanced ailerons on the upper wings, the framework of which is composed of 10 mm. steel tube. In both planes the trailing edges are rigid. The spars are of pine, and separated in each plane by about half the chord length; the front spars are in each case very near the leading edge. The central portion is covered with 3-ply, and is cut away considerably above the pilot's seat. A petrol tank and a radiator are lodged in the thickness of this portion of the wings. The lower wings are very much twisted at the tips.

There are two pairs of wing struts, one on each side of the fuselage, and they are of faired steel tube. They are reinforced internally by a double tube at their ends. At the points of attachment of the struts the spars are reinforced by four plates of ash, and are furnished with metal collars carrying ball and socket joints for fixing strut and cable ends.

The cabane is divergent, and consists of six struts, slightly inclined forward. Two of these are attached to the front spar, and the other four form a pair of inverted V's with the apexes at the rear spar.

The tail recalls that of the Albatross, but the fixed plane is less deep and has a less rounded leading edge. The structure is metallic, and the 30 mm. tube forming the leading edge is placed between two strips of ply wood. The elevators are not balanced, but the rudder is. The latter is situated with the fixed fin entirely above the fuselage, and the elevators extend some distance beyond the trailing edge of the rudder.

The fuselage is of ply wood, and terminates in a horizontal knife edge. It is of light construction, and well faired. The sides and base are flat, and the top rounded. At the forward end the covering consists of two sheets of light alloy joined at top and bottom of the fuselage.

There is one elongated cockpit for pilot and machine gunner. Under the pilot's seat is the main petrol tank. The machine gunner is in the rear and is rather cramped. The turntable is raised above the top of the body, thus ensuring an excellent field of fire.

The under-carriage is provided with two pairs of steel tubes, each forming a V; the tubes are widely separated. The shock absorbers may be either rubber or steel springs.

The Halberstadt C.L. II. has a good reputation among German fliers, but probably more on account of its good manœuvrability than of its performance. Its ceiling does not exceed 16,500 ft., and its speed is 103 m.p.h. on the ground against 85 m.p.h. at 13,000 ft. ("L'Aerophile," December 1-15, 1918.)

Duesenberg Model H. 850 h.p. Motor.

The Model Duesenberg motor, developing 850-900 h.p., built by the Duesenberg Motor Corporation, of Elizabeth, N.J., is the most ambitious aero engine development that has been attempted, and carried through successfully, in the United States. The motor is of the 16-cylinder, V type, with cylinders at an angle of 45 deg., and the weight of the power plant with gear drive is 1,575 lbs., without gear drive 1,390 lbs.—remarkably low weight ratio for a power plant of its size.

General Data.

Number and arrangement of cylinders: Sixteen V.
Included angle: 45°.
Bore: 6″.
Stroke: 7½″.
Normal brake horse-power: 800 at 1,800 r.p.m.
Type of gear: Overhead camshaft and valve rockers.
Number of carburettors: Four Miller.
Number of valves per cylinder: One inlet and two exhaust.
Type of piston: Flat.
Material of piston: Magnalite.
Number of camshaft bearings: Four bronze and one ball bearing.
Cylinder centres: 7 inches.
Ignition: Battery and generator.

Many further particulars are given in the article, together with drawings and photographs of the engine and separate parts. ("Aerial Age Weekly," January 27, 1919.)

German Two-Seater Biplane L.V.G. C. VI.

This machine is one of the most recent that have been brought down on the French front, and may be considered an improved form of the L.V.G. C. V. There are no new features, but the improvements noticed in the latest German designs are embodied in the C. VI.

The principal dimensions and the weight of the C. VI. are rather less than those of the C. V., whilst the motor is still the 225 h.p. Benz, so that presumably there is an improvement in the performance.

The wings are unequal in span and chord, without sweepback, slightly staggered positively, and have a dihedral. The ailerons carried by the upper plane only are no longer balanced, and do not project beyond the maintips. There is a small fixed central portion which carries the radiator within its thickness. A petrol tank is lodged in the left-hand wing. The leading edge of the upper wing

is shorter than the trailing edge, whilst the tips of the lower wings are approximately elliptical.

The six struts of the cabane are in two groups of three tubes, each forming an N inclined towards the rear. They are not inclined in the front view.

The tailplane is a little larger than in the C.V. Elevators and rudder are balanced, and the rudder is placed wholly above the tailplane.

The fuselage is of ply wood, and finishes in a vertical knife-edge. The sides and base are slightly convex, and the top is considerably rounded.

The mean duration of flight is about 3¼ hours. ("L'Aerophile," December 1-15, 1918.)

The Standard E1 Single-Seater.

The E1 single-seater built by the Standard Aero Corporation was designed as a secondary training machine. It is provided with either an 80 h.p. Le Rhone or a 104 h.p. Gnome engine, but in either case the dimensions of the machine remain the same. Slight differences in weights and performances result, depending upon which engine is used.

The R.A.F. 15 wing section is used. Dihedral 3 deg.; aspect ratio of both planes, 7; stagger, 13.02 in. Wings are set at an angle of 2 deg. to the propeller axis.

General Dimensions.

	Ft.
Span, upper plane	24
Span, lower plane	24
Chord, both planes	3.5
Gap between planes	4
Length over all	18.85
Height over all	9.08

Areas.

	Sq. ft.
Upper plane	81
Lower plane	72.3
Ailerons (two upper and two lower)	23.2
Total wing area with ailerons	153.3
Stabiliser	12
Elevator	12.7
Fin	2.6
Rudder	6.8

Summation of Weights.

(With Le Rhone Engine.)

	Weight in lbs.	Percentage of gross weight.
Power plant	434	36.4
Fuel and oil	140	11.8
Pilot and miscellaneous equipment	179	15.1
Armament	28	2.4
Body structure	141	11.9
Tail surfaces and bracing	36	3.1
Wing structure	156	13.1
Chassis	74	6.2
Total	1,188	100.0

Summation of Weights.

(With Gnome Engine.)

	Weight in lbs.	Percentage of gross weight.
Power plant	467	36.6
Fuel and oil	196	15.4
Pilot and miscellaneous equipment	179	14.0
Armament	28	2.2
Body structure	141	11.1
Tail surface with bracing	36	2.8
Wing structure	156	12.2
Chassis	74	5.7
Total	1,277	100.0

Weight per h.p.: Le Rhone 14.5
Weight per sq. ft.: Le Rhone 7.6

The Le Rhone is a nine-cylinder, air-cooled rotary engine, developing 80 h.p. at 1,200 r.p.m. and 84 at 1,290. Bore and stroke $4^{1}/_{16}''$ by $5\frac{1}{2}''$.

The nine-cylinder rotary Gnome, manufactured by the General Vehicle Company, is known as type B-2. At 1,200 r.p.m. it delivers 104 h.p. Bore and stroke, 110 mm. by 150 mm.

Summary of Performances.

(With Le Rhone Engine.)

Height (feet).	Speed (m.p.h.).	Time of climb. min.	Time of climb. sec.	Rate of climb (ft. per min.).
Ground	100—103	0	0	705
5,000	—	8	0	705
5,500	95	—		—
8,500	90	16	30	—
10,000	85	22	20	200

Ceiling: 14,500 ft.
Stalling speed: 48 m.p.h.
Gliding angle: 1 : 7.
Maximum range: At 5,000 ft., 200 miles; 10,000 ft., 160 miles.

In the article detailed weights of parts are given, and it is illustrated with general arrangement drawings and photographs of the machine. ("Aerial Age Weekly," January 27, 1919.)

Formula for Approximating Propeller Diameter.

In this article a simple and effective formula is obtained for determining the diameter of a propeller giving an estimate of fair accuracy for any case in which the number of blades, the horse-power and r.p.m. of the engine, the flying speed and the maximum blade width are given. In deriving this formula it is assumed that the efficiency is the same for all propellers, so that the horse-power absorbed is proportional to the product of the thrust and the speed of flight. It is contended that practice shows that this assumption involves only comparatively small errors. On the Drzewiecki theory of design the thrust on an element is

$$T = K_y \times b \times dr \times V^{2}_{r} \times \cos(A + G),$$

where K_y is the lift coefficient of the section; b the blade width; dr the length

of the element; V_r the resultant velocity through the air; A the angle which the path of the element makes with the plane perpendicular to the propeller axis; and G the angle which the line of action of the resultant force on the element makes with the perpendicular to the path of the element. The value of b is directly proportional to the maximum blade width so long as the blade form remains unchanged. Therefore to allow for changes in section and in plan form arbitrary constants will require to be associated with Ky and b respectively. Assuming the propellers divided into the same number of elements, dr is proportional to the diameter and V_r to the product of the diameter and the number of r.p.m.

Cos $(A+G)$ is practically constant for all propellers. On these assumptions it is easily shown that the power absorbed can be written in the following form:—

$$P = \frac{K_1 K_2 B D^3 N^2 V n}{10{,}000{,}000{,}000}$$

D = propeller diameter (ft.).
B = maximum developed blade width (in.).
N = revolutions per minute (of propeller).
n = number of blades.
V = speed of flight (m.p.h.).
K_1 = coefficient of blade form (0.75—1.00).
K_2 = coefficient of section and angle (0.75—1.00).

For propellers of the usual blade form with a rounded tip, and the maximum width about three-quarters of the way out.

$$K_1 = 0.85 - 0.9.$$

K_2 has its maximum value for propellers with a cambered blade at a large angle of incidence (about 6 deg.), its minimum for sections of low-lift type set at a small angle (about 2 deg.).

K_2 also will lie between 0.85 and 0.9 for most propellers, so that it is not possible to make a very large error in the determination of these constants.

As an illustrative example, the diameter of a two-bladed propeller for the Liberty engine, developing 400 h.p. at 1,700 r.p.m. mounted on an airplane flying 125 m.p.h., may be found, assuming the maximum blade width to be 10 in.

$$400 = \frac{0.85 \times 0.9 \times 10 \times D^3 \times (1{,}700)^2 \times 2 \times 125}{10{,}000{,}000{,}000} = 0.553\, D^3$$

$$D = \sqrt[3]{\frac{400}{.553}} = 9.0 \text{ ft.}$$

(E. P. Warner, "Aviation," February 15, 1919.)

Nomographic Charts for the Aerial Propeller.

There has recently come into use a means for the graphical solution of exponential formulæ, which is similar in principle to the "Polar Logarithmic Diagrams" devised by M. Eiffel, in that it depends on the reduction of an exponential to a linear form by the use of logarithms, and the employment of logarithmic scales. This device consists in the construction of diagrams called nomographic charts, or alignment charts, from which the required results may be obtained by simply connecting the points representing the given data by straight lines and then reading off the intercepts on the proper scale, the method being similar to that of using a slide rule.

Prof. Slocum describes with examples the method of applying nomographic

charts to propeller calculations, assuming that the performance of a given type of propeller is given by an exponential formula based on actual results of tests. He states that the usual assumptions that the thrust varies as N^2D^4 and the horse-power as N^3D^5 may often give erroneous results, as was found by analysis of experimental results obtained by M. Eiffel and Capt. Dorand. ("Aerial Age Weekly," January 27, 1919.)

Plywood in Aeroplane Construction.

The first point upon which stress is laid in this article, describing the many uses to which plywood may with advantage be put, is that the idea of a number of sheets and fragments of thin wood stuck together by an adhesive such as ordinary glue, more or less soluble in water, or swelling and loosening on exposure to atmospheric humidity, should be dismissed from the mind when the material "plywood" is under consideration.

True plywood is a product resulting from a scientific process involving a correct and methodical sequence of operations all depending on each other. The elements of the original structure of the wood; the relations of the particular cementing material employed to the wood and to the atmospheric conditions of the moment; the temperature required to produce the chemical reactions between the wood and the cementing material, and within the cementing material itself; and the magnitude and duration of the pressure applied per unit area; all these form such a number of variables that no routine standardisation is practicable, and only the exercise of individual skill obtained under long experience, can produce a determinate result.

Laminated plywood formed into shapes under heat and high pressure with cementing materials which become insoluble in the course of the process, has been used in Russia for many years, notably in the works of the Russian Baltic Wagon Co., Ltd., who made the plywood fuselage of the Sikorsky aeroplane. From Russia the use of plywood extended to Germany in the products of the Deutsches Rohrplatten Gesellschaft; from which a knowledge of these special processes and equipment passed to the United States nearly twenty years ago. In Russia Capt. Kostovitch used plywood for dirigibles which in construction and design anticipated the most recent rigid plywood dirigibles built by the Schutte-Lanz Company in Germany. In Russia also the first complete plywood aeroplanes were made by Steglau in 1912, the use of plywood extending even to the wing covering.

In France, as early as 1909, sheet plywood was used by Levavasseur, and later, in 1912, Béchereau, of the Deperdussin Company, designed the fuselage now known as the "monocoque."

The Germans, who at first made fuselages of the truss type, covered in with linen after the prevailing French style, commenced about 1912—probably following on a visit of one of their investigators to Russia—to use plywood in fuselage construction, following not the method of Béchereau but a more correct method employing longerons and bulkheads.

England and France continued to use the linen-covered truss construction, and the designers of the United States in most cases followed the precedents thus created with little or no regard to what had been developed in Russia and Germany.

It is pointed out what rough usage the fuselage of the Albatross aeroplanes are able to withstand, and that the use of plywood on British and French machines is even yet unlike that of the better constructed German aeroplanes in that the plywood is generally nailed on as a mere covering, and not made an integral part of the structure.

Among the advantages of plywood as against the truss construction are the facts that no periodical truing up is required, and that the wood for plywood being so thin may be dried very quickly. The real problem in its successful use in aeroplane construction lies in the standardisation of parts for quantity production. (H. H. Suplee, "Aerial Age Weekly," January 20, 1919.)

Winds and the Trans-Atlantic Flight.

From meteorological data obtained both on the American and the European sides of the Atlantic it is possible to specify with moderate certainty the conditions that would confront a pilot attempting a trans-Atlantic flight, to indicate approximately what course should be followed, and which heights are the most favourable. In 1905-07 four expeditions were undertaken for the purpose of exploring the atmospheric conditions in the inter-tropical regions of the Atlantic. By measurement of the speed and direction of ascent of balloons from the deck of a yacht, the velocity and direction of the wind up to 30,000 ft. was determined between 10° and 30° north latitude, and 60° and 40° west longitude during the summer months. In all 715 observations were taken: 74 per cent. of the winds at sea level came from north-east, and this direction was more frequent than any other up to 10,000 ft. At 20,000 ft., east and south-west winds became most common, and at 30,000 ft. south-west winds were strong and frequent. The steady north-east Trade Wind blowing near the surface of the sea would be a distinct aid to a westward flight. These winds at sea level vary from 10 to 15 m.p.h., increasing to 25 m.p.h. at 20,000 ft.

From these data it is concluded that a very favourable course could be taken in the summer at a height of 3,300 ft., starting from Boston in an east-north-easterly direction. From 30° west certain Manchester observations could then serve as a guide, for these indicate that at this point favourable winds from the north-west are prevalent, thus encouraging a change in the course to one almost due east, with London as an objective. Observations show that fair weather and few storms prevail over this route in summer, and it is high enough to be above the fog. ("Aviation," February 15, 1919.)

"Planeurs Captifs" for Meteorological Work.

The author holds strongly that there is a great future for scientific kite flying for meteorological work, aerial photography, signalling, etc. Numerous societies existed in France before the war for the encouragement of kite flying, but the work of these in educating the public to the importance of the subject was interrupted by the outbreak of hostilities. It is proposed that an association should be formed embracing all such societies, and that there should be close co-operation between the different workers. Government assistance is desired especially in the provision of suitable grounds for the experiments in different parts of the country. The work must be carried out in a scientific manner, and all results of importance published. It is recommended that the name "kite" (cerf-volant) be dropped as being suggestive of a toy, and "Planeur Captif" adopted instead. The features which the apparatus should embody are sketched out. Thus the kites should be easily collapsible for storage, and yet rigid when erected. They must be stable in flight, and must act as a parachute if a sudden drop of wind occurs. They should fly in winds of from 5 to 25 m.s. In the scheme outlined for man lifting a pilot kite is first sent up and the train of lifting kites attached to the cable at intervals of 10 to 30 m. A basket travelling up the cable is used for the observer. the winch is preferably mounted on a lorry with separate motors for winding in the cable and driving the lorry. A dozen men have been found to be sufficient to manipulate a train of man-lifting kites. Sketches show several suggested forms of kite both of the monoplane and box types. Details of construction are also shown. ("L'Aerophile," January 15, 1919.)

Speed Measuring Instruments for Aeroplanes.

The conclusion of an article on speed measuring instruments for aeroplanes and airships first describes a double indicator which shows the revolutions per minute of both the right and left hand driving motors. The two speed cards are in one case and are clearly marked from four to sixteen hundred r.p.m. In this casing is fitted the magnetic coil which itself carries the indicators, so that

all gearing is avoided, the movement of the indicator needle being limited to an angle of 90°. The needle for the L.H. motor moves underneath the needle of the R.H. motor, and the reading especially on the higher numbers is very clearly seen.

In spite of their simplicity these double speed indicators have not come into general use, their disadvantages being that if a speedometer has to be changed the whole apparatus must be taken to pieces.

The anemotachometer is another important instrument for aircraft, for measuring the actual or relative speed of the flying machine. It is made in the form of a cross, each arm of which carries a cup-shaped impeller which the wind drives. The rotation of the wind-driven impeller on its central spindle actuates a pendulum movement, the strokes of which are transmitted to the indicating dial. One of the greatest advantages of this instrument is that its action is always positive and is not affected by the density of the air through which the aeroplane is passing and, further, that the anemotachometer comes into action immediately the machine starts.

As this instrument has to be near the driver's seat, in large flying machines the same four-cup cruciform anemotachometer is used, but in this case the control is electrical and the flying speed is given by the voltmeter above the pilot's seat. This instrument has a second valuable use in that from it the pilot can judge the curvature of his course. Owing to the number of motors which are now included in the design of one aeroplane, steering has become very difficult, and it is often impossible for the pilot to know in foggy weather whether he is steering in a curve or straight forward. If two anemotachometers electrically connected to a central voltmeter are placed towards the extremity of each wing of the aeroplane, then the indications of both instruments will be the same if the machine is flying straight, but if flying in a curve the instrument on the inner or shorter radius of the curve will register a slower speed than the one on the outer radius. From the difference between these indicated speeds, the curvature can be seen from a properly prepared chart on the indicator dial.

The article is concluded by a description of various ways in which the anemotachometer may be used and different methods of the electrical wiring of the instrument, with various graphs and diagrams to illustrate the text. (Wilke, "Der Motorwagen," December 31, 1918.)

Helium for Airships.

One of the greatest achievements due to the pressure of war conditions, from the technical point of view, is the production of helium in quantities sufficient for airships. A rare gas discovered by Ramsay about twenty years ago, not more than 100 cubic feet had been obtained up to two years ago. Someone in the British Admiralty had imagination enough to propose the separation, on a large scale, of helium from natural gases in Canada, which gases contain about one-third of 1 per cent. of helium, and experiments were undertaken at the University of Toronto. The U.S. Bureau of Mines took the question in hand, and with such success that on the cessation of hostilities in Europe, there was, compressed and on the dock ready for floating, 147,000 cubic feet of nearly pure helium, and plants were under construction to produce at least 50,000 cubic feet a day at an estimated cost of not more than ten cents a cubic foot. The gas, which is non-inflammable, has about 92 per cent. of the lifting power of hydrogen. ("Engineering and Mining Journal," February 8, 1919.)

Commercial Employment of Rigid Airships.

The general public consider Zeppelins a failure, but are not aware of the important services airships rendered to the navy. The author describes the patrol duty carried out round the coasts of England and Scotland by airships. On

October 31, 1918, there were more than 100 such vessels in England. One had remained in the air 55 hours and another 61 hours. The British Navy has nine vessels of the Zeppelin type in use and others are being built. The American Congress has voted funds for six such vessels. In France it was decided to build six, but work upon the first has already been stopped. The author considers that airships and aeroplanes are not rivals, but that each has its special field of usefulness and travelling will be much more comfortable in the former than in the latter. He believes that airships will be largely employed for the conveyance of goods in districts where no railways exist. He looks forward to a regular traffic by airship from Europe and America, and regrets that the airship is at present neglected by the French naval authorities. ("Génie Civil," March 1, 1919.)

Aeronautics in the United States.

The author reviews the war developments of aeronautics and research relevant thereto in the United States. Helium has been made in balloon quantities, 147,000 cu. ft. being ready for shipment when hostilities ceased and plants being under construction to yield 50,000 cu. ft. per day at a cost not exceeding 10 cents per cu. ft. This gas has 92 per cent. of the buoyant effect of hydrogen and is non-inflammable. The meteorological service has made important discoveries bearing upon air currents at various altitudes and the possibilities of using airships for long distance flights. Arrangements have been made to take balloon records right across the Atlantic. A review is given of aero-radio development work, notably in connection with vacuum tubes, radio-telephony and direction finders. (G. O. Squier, "Electrical Review," Chicago, January 25, 1919.)

Newest Type of Zeppelin Cruiser.

All the latest improvements that the Germans had achieved were embodied in a Zeppelin which made a forced landing in France in October, 1917. Since that time no change has taken place in any essential feature. In length the airship is about 200 metres, the total height 24 metres, and its volume 57,000 cu. m. In form the central portion is cylindrical, and the two ends taper to a cone. Of the four gondolas one is placed well forward; this is divided into two compartments, in one of which there is the commander's cabin and the wireless telegraphic apparatus, while in the other the motor is fixed. Approximately amidships, side by side, are two other gondolas, each of which is also furnished with a motor. The fourth gondola, situated close to the tail, contains two motors, one of which is held in reserve for emergencies.

A triangular passage is built into the lower part of the envelope and is completely covered in. A ladder connects the gondolas directly to this passage. A wooden construction in the centre of this passage contains the fuel, the water ballast, the bombs, and several hammocks. A cylindrical chimney, constructed of a series of metal rings, connects this passage to a platform on the top side of the airship, where machine-guns and other light weapons are stationed. The four gondolas are well streamlined. The most forward of these is 10 metres long, 6 metres of which is taken up by the cabin of the commander. In height this chamber is $2\frac{1}{2}$ metres and in breadth $2\frac{1}{4}$ metres. The motors develop approximately 1,200 h.p., while the diameter of the four propellers is 5 metres. The fuel tanks are of aluminium, and hold 300 litres of benzine.

The water ballast tanks have a capacity of 1,000 litres. The normal speed of this airship amounts to 100 kilometres per hour, while journeys of 30 hours' duration were undertaken without any difficulty. With a good climbing capacity the airship can attain heights of 5,500 to 6,000 metres.

The wireless telegraphic apparatus is built after the Telefunken system, and can transmit waves of lengths varying from 300 to 1,700 metres with the aid of antennæ 120 metres in length. ("Automobil-Welt," January 5, 1919.)

German Single-Seater Scout, Roland D.VI.

This machine appeared at the front in July, 1918. There are two forms, identical in every respect except that that D.VI.a has a 180 h.p. Mercédès engine and a weight empty of 1,440 lbs., whereas the D.VI.b has a 200 h.p. new model Benz engine and a weight empty of 1,475 lbs.

The fuselage is covered with strips of wood, tongued and grooved in a manner recalling canoe construction. There is a metal cowling forward for the motor. The tailplane is all in one piece, passing through the body. Balanced rudder and elevators are fitted. The fuselage has an elliptical section, shaped locally to form a short keel, to which the lower wings are attached.

In the lower part of the body and immediately behind the airscrew is a gilled oil cooler radiator.

The wing struts are wooden and tapered, a single pair to each wing attached to the spars by ball and socket joints.

The planes are staggered a little, and there is a dihedral on the lower wing only. The ailerons, fitted to the upper plane only, have a very narrow chord and are balanced by horns extending beyond the wing-tips. The Fokker D.VII. and all subsequent scouts have ailerons of this form.

The water radiator is in the upper plane. The new Benz engine has a new method of circulating the cooling water. The outlets for the jacket water are placed on the exhaust side of the cylinder head, and not in the centre at the top as formerly. This ensures better cooling of the exhaust valve. The lower system of communication between the jackets consists of a collector tube separated from the motor, to which the inlets of the various cylinders are attached independently by rubber tubes and flanged joints.

The construction of the machine is very ingenious but too frail in many parts. Thus the wing ribs have webs of linden, and flanges of ash. Linden or lime wood is not strong enough and reinforcing strips have to be nailed and glued on at several parts of the web. The spars are of northern red pine of good quality, and are made in box section. The finish is much improved as compared with previous German practice. (" L'Aerophile," January 1, 1919.)

Radio-Surgical Machine—" Aerochir."

This is a weight-carrying machine designed to carry a surgical outfit. It is the result of the collaboration of the engineer M. Nemirovsky and the doctor Tilmant, and is built to carry a pilot, a surgeon, and an X-ray operator as well as a complete surgical outfit. The speeds of machines for this purpose range from 60 to 100 m.p.h. A comparison of this rate of travel with that of wheeled traffic on congested military roads will indicate the immense value of the machines in war for the treatment of urgent cases. The scene of a sudden action leading to a large influx of wounded can be reached in less than two hours after warning has been received at the central station, if a post with two machines be provided for every 120 miles of front. In peace time also the machines should prove invaluable.

The " Aerochir " contains all the material necessary for six urgent operations to be performed immediately on arrival, and for sterilising this material for the performance of a subsequent 30 operations. There is a complete outfit of X-ray apparatus, the bulb being carefully protected by means of a fixed and padded box. The operating table is of specially light construction, entirely in sheet aluminium (which is permeable to the X-rays); it can also be used as a stretcher. The remaining surgical appliances are housed in aluminium boxes.

The total weight of the material carried by the " Aerochir " is about 800 lbs. All the trials have given full satisfaction. (" L'Aerophile," January 1-15, 1919.)

German Educational Work.

The paragraph on German educational work in aeronautics which appeared in the April number of this journal (Vol. XXIII., p. 203) is worthy of attention. Captain A. Graham Clark writes in reference to it as follows:—

The list of lectures is of more than ordinary interest as indicating the importance attributed by Germany to a strong aeronautical educational programme—despite the conditions imposed by the war. In the "Deutsche Luftfahrer Zeitschrift" for June, 1917, it was noted that the summer programme for 1917 was virtually only the same as in the preceding term. The summary of these lectures was as follows:—

UNIVERSITIES.

COLLEGE.	LECTURER.	TITLE OF LECTURE.
Berlin ...	Marcuse ...	Topographical geography with exercises in nautical geography and aeronautical astronomy.
Münster ...	Schewior ...	Outline of aeronautics.

TECHNICAL COLLEGES.

Aachen ...	von Karman..	Aerodynamics of flight.
Berlin ...	Kassner ...	The wind—its origin, measurement and application in relation to the construction of high buildings and harbours, to sea and airship navigation, and also to the construction of wind driven engines.
Berlin ...	v. Parseval ...	Aeroplanes.
Berlin ...	Schaffran ...	Researches with air and water propellers.
Brunswick ...	Schlink ...	Meteorology and aeronautics.
Danzig ...	Fottinger (subst. N.N.)	Propellers for water and aircraft—the design of propellers for water and aircraft.
Danzig ...	Rieppel (subst. Dr. Eng. Schneider)...	Engines for land, water and aircraft.
Darmstadt ...	Schleiermacher	Aerodynamics in relation to airship navigation.
Hannover ...	Precht ...	Airship navigation.
Hannover ...	Pröll ...	Aero-mechanics in their application to dirigible airships and aeroplanes.
Munich ...	Emden ...	Construction and navigation of the airships.
Stuttgart ...	A. Baumann...	Aeroplanes and their constructional details. Engines for land, water and aircraft.
Graz ...	Wittenbauer...	Technical Mechanic II. (hydrostatics, hydraulics, the mechanics of gases). Aeroplanes and airships in flight.
Vienna ...	Knoller ...	Airship navigation and the automobile.

All the above, with the exception of that at Münster, are included in the 1918 programme, but the whole syllabus has now been more widely extended on a much broader basis and the prominence which is now given to those subjects that are of high importance in commercial aeronautics should be particularly noted, as well as the attention devoted to propellers and to airships. The fact that such extension was deemed possible in 1918, when the syllabus remained practically unchanged in 1916 and 1917, is significant.

ABRIDGMENTS OF RECENT PATENT SPECIFICATIONS (AERONAUTICS).

122,060. L. Lightman, 89, Harehills Avenue, Leeds. February 1, 1918.

Jigs for making Aeroplane Ribs, etc.—A jig, particularly for use in securing edge frames to the ribs of aeroplanes, comprises a base having a series of parallel cross slots over each of which is a pair of plain square blocks carried by bolts passing through the slots so that the blocks may be adjusted to suit ribs of different contour. The base may be of wood, and comprises separate strips spaced apart to form the slots, or may be of cast iron and provided with slots extending only part way across it. A templet of the rib is placed on the base and the blocks adjusted to its periphery and secured by bolts. The templet is then removed and the rib with the glued edge frames placed on it is pressed down by hand between the blocks, and the frames are then screwed or nailed to the rib. Blocks may be provided to engage the ends of the ribs, and the lower face of the blocks is, preferably, covered with sand-paper.

122,061. G. Anderson, 14, Palgrave Road, Shepherd's Bush, London. February 4, 1918.

Clinometers.—An instrument for use on aircraft, comprises a shallow cylindrical box containing pivoted therein a pendulum bearing an arm which moves over a luminous scale on the edge thereof. The box carries a spindle mounted in ball bearings, and carries a pointer which moves over a luminous scale and indicates inclination in a plane at right-angles to that indicated by the first mentioned scale.

122,080. H. F. Wilson, 25, Howley Place, Maida Hill, London. March 15, 1918.

Aerial Warfare.—Consists in providing aeroplanes with an adjustable cutting-blade for ramming enemy aircraft. The blade is hinged in front to the aeroplane, and is adjustable vertically at the rear end by means of a curved extension movable within a socket. The blade is fixed in the adjusted position, whether extended for action or folded in for landing, by means of a pin fitted through a transverse hole in the socket and one of a set of holes in the extension of the blade. Modifications are described comprising (1) a blade hinged at the rear end, and (2) a separate rod sliding in the socket and pivoted to the blade instead of the extension on the blade.

122,164. P. B. Van Leggelo, 2405, West Sixth Street, Los Angeles, California, U.S.A. April 3, 1918. Convention date, January 5. Not yet accepted. Abridged as open to inspection under Sect. 91 of the Act.

Aerial Machines without Aerostats; Cars and Cabins; Parachutes.—A helicopter machine, comprises square or other shaped frames connected together by posts, and covered with wire mesh to form a compartment for the pilot, etc., and an adjustable propeller driven by a motor. A parachute is normally collapsed under a cover, its outer end being attached to frames, which are spring-hinged to slides subject to the upward pressure of springs. When the parachute is closed by means of cords, the frames lie against the sides of the compartment, and are retained at their upper ends by catches. When the catches are released by means of cords, the parachute is automatically extended by its springs. Reflectors may be swung out underneath the machine for rendering the car invisible from below.

Propelling; Steering.—The shaft of the propeller is universally jointed, and may be moved in any direction by means of a hand-wheel and a lever moving over a sector. The motor may be suspended below the joint or may be above it.

Planes, Arrangement of.—Vertical planes are provided for preventing rotation of the car.

Land Wheels.—The floor of the car is provided with extensions at each corner carrying swivel wheels.

122,200. E. Barnes, Newton Works, Eyre Street, Sheffield, and L. H. Chase, Pleasant Place, Cardington, and R. W. L. Phillips, 5, Newnham Road, both in Bedford. June 14, 1916.

Range-finders.—A range-finder for use against aircraft comprises two sighting devices, which are placed at the ends of a base-line and are each capable of rotation about a horizontal and a vertical axis. The movements of one of the sighting devices are imparted to a vertical screen (or equivalent) rotatable on a vertical axis and to a pointer rotatable on a horizontal axis carried by the screen, and the movement of the other sighting device about its vertical axis is imparted to an optical projection device, which is rotatable about a vertical axis spaced away from the vertical axis of the screen by a distance representing the base-length, and indicates on the screen a vertical plane passing through the axis of rotation of the projection device. The inter-section of the plane indicated with the pointer gives the position of the object sighted. In the construction shown, the sighting device is mounted on a platform which forms the roof of a chamber having within it the range-indicating apparatus. The vertical screen, which is preferably translucent, is carried on a spindle on which the sighting device is mounted. The pointer pivoted on a horizontal axis is maintained parallel to the sighting device by means of a tape passing over pulleys. The projection device is carried by a receiver connected to a transmitter actuated by the movements about its vertical axis of the other sighting device, the transmission mechanism preferably being that described in Specification 122,424. The receiver is mounted on a rod fixed in a radial position to the casing supporting at its upper end the sighting device. The projection device comprises an electric lamp having a straight filament arranged in a casing with a narrow slit. A wire is provided to cast a shadow. A mirror is provided to reflect the beam of light over a wide angle. The screen may be ruled with lines in addition to the height and distance, to give information such as the time of flight of a projectile. The screen may also be fixed and the arms carrying the projector may be made to rotate in the opposite direction to the telescope. Or the arm may rotate with the telescope and the projector device be turned in the opposite sense to the other telescope. The screen may be replaced by a framework carrying a vertical pointer capable of being horizontally traversed. A small target screen may be provided on the vertical pointer. More than two sighting devices may be employed.

122,302. J. E. Thompson, Paisley, Ontario, Canada. February 21, 1918.

Screw Propellers.—In an aeroplane propeller, the blades are journalled in radial sleeves carried by a cone shaped bearing member secured at its apex to the propeller shaft. A sliding sleeve on the shaft, and operated by the lever, has tangential racks which gear with corresponding pinions on the blades.

122,325. A. G. France, 64, Chancery Lane, London. March 20, 1918.

Wire and Rod Strainers.—Relates to screw turn-buckles, applicable for straining aircraft stay wires, and consists in effecting the locking of the screw by means of co-operating conical surfaces. In the form shown, the attachment stirrup is formed with a hollow conical sleeve and the nut situated within it, also is made taper and has radial slits, enabling it to be sprung slightly. The nut has

a square aperture for the insertion of a rotating tool, and tommy-holes for a like purpose. Alternatively, the nut may have a squared, etc., part projecting beyond the conical portion of the stirrup, whereby it may be rotated.

122,426. J. de Lesseps and R. Courtois-Suffit, 1, Rue d'Astorg, Paris. January 15, 1917. Convention date, July 19, 1915.

Instruments for use on Aircraft.—Apparatus for indicating whether the course of an aircraft is straight or curved, so that the pilot may, if necessary, steer the aircraft into a straight course before reading the clinometer, comprises two air inlets connected by pipes to pressure chambers capable of operating an indicating needle through linkwork; the apparatus indicates also the speed of the aircraft. The inlets may comprise Pitot, Venturi, Baudin, or other tubes, and are preferably placed at the greatest possible distance from the plane of symmetry of the aircraft and in positions in which the local relative speed of the air is greater than the speed of the aircraft. The pressure measuring chambers are of diaphragm or other type. The linkwork comprises a parallelogram of links pivoted at the corners, and links connecting the parallelogram to the pressure chambers. The needle, which may be pivoted, passes through a slide and indicates on a scale. When the course of the aircraft is straight, the pressures in the inlets are equal, and the needle is at the zero position on the scale, but when the course is curved, the pressures are unequal and the needle is consequently displaced from zero. The needle may have graduations so that the position of the slide over the graduations indicates the speed of the aircraft. The clinometer may comprise a damped pendulum, operating an indicating needle moving in front of the dial bearing the scale.

122,427. Soc. Esercizio Bacini and Gogliolo, T. S., 33, Via XX Settembre, Genoa, Italy. February 3, 1917.

Screw Propellers.—Comprises the design of an aerial or marine propeller blade of minimum lateral surface projected on a lateral plane to the axis from a standard blade without loss of pitch. A graphical process is described and illustrated for designing the blade from the traces of a standard blade, and consists in setting out the sinusoids of such a blade, projecting on the sinusoids the elements of circular sections of the blade, displacing the smaller spirals parallel to the axis so as to cross the spirals immediately greater and joining the points of intersection, and displacing the generatrix to correspond.

122,458. Regent Carriage Co., and J. Boca, 126, New King's Road, Fulham, London. January 22, 1918.

Wire Strainers.—An aeroplane stay wire strainer comprises a right and left handed screw, engaging square nuts housed within U-shaped members formed from sheet-metal blanks of the shape shown in the drawings, the screw passing through central holes. The ends of the blanks may be connected by a hollow rivet or by a headed pin.

122,506. S. E. Saunders, Ltd., and H. H. Thomas, Columbine Works, Medina Road, East Cowes, Isle of Wight. February 5, 1918.

Stays for Aircraft Framing, etc.—Stay or tension members for use in aircraft, bridges, or other structures are constructed of several wires laid parallel to one another within an outer covering, the whole being subsequently drawn or rolled to the desired section. The wires may be treated with bitumen, paraffin, etc., which fills the interstices.

122,602. N. E. Dufty, 57, Tulse Hill, Surrey. September 6, 1918.

Lubricating.—The gudgeon pins and pistons of high-speed aeroplane engines and Diesel engines are supplied with lubricant by means of the oscillation of the

connecting rod. Lips on the connecting rod move towards and from a fin formed on a crown piece fixed to the piston. The air in chambers is compressed and forces oil which has drained into the chambers through holes leading to the gudgeon pin. Holes through the gudgeon pin and piston may convey oil to the outer surface of the piston.

122,646. J. W. Rapp, College Point, New York, U.S.A. (Assignee of J. Vanorio, College Point, New York, U.S.A.) January 20, 1919. Convention date, January 19, 1918. Not yet accepted. Abridged as open to inspection under Sect. 91 of the Act.

Land Wheels.—A running-gear for aeroplanes comprises, at each side of the fuselage, hollow metal struts provided at the top with hinging knuckles, and connected together and to a plate at their lower ends. The plate provides a half-bearing for the axle.

122,647. J. W. Rapp, College Point, New York, U.S.A. (Assignee of J. Vanorio, College Point, New York, U.S.A.) January 20, 1919. Convention date, January 19, 1918. Not yet accepted. Abridged as open to inspection under Sect. 91 of the Act.

Cars; Framework.—The fuselages of aeroplanes are composed of steel tubular longerons of rectangular cross section connected together by cross stays and struts of similar tubes. The longeron tubes are made of sections of tubing of different dimensions telescoped and welded together.

122,648. J. W. Rapp, College Point, New York, U.S.A. (Assignee of J. Vanorio, College Point, New York, U.S.A.) January 20, 1919. Convention date, January 19, 1918. Not yet accepted. Abridged as open to inspection under Sect. 91 of the Act.

Aeronautics; Girders.—An aeroplane rib is formed as a box girder stamped from a metal sheet, or two sheets. In the former case a flange is provided for welding, and in the latter case, either flanges or abutting edges. The sides are cut out to form braces, which have their free edges bent inwards.

122,649. J. W. Rapp, College Point, New York, U.S.A. (Assignee of J. Vanorio, College Point, New York, U.S.A.) January 20, 1919. Convention date, January 19, 1918. Not yet accepted. Abridged as open to inspection under Sect. 91 of the Act.

Girders.—Aeroplane ribs are formed from a single sheet of metal, and comprise beads with intermediate web parts cut and embossed into truss formation. Lugs also are provided for attachment to wing spars. The web portions may be formed of W-section, or of V-section, with beads.

122,650. J. W. Rapp, College Point, New York, U.S.A. (Assignee of J. Vanorio, College Point, New York, U.S.A.) January 20, 1919. Convention date, January 19, 1918. Not yet accepted. Abridged as open to inspection under Sect. 91 of the Act.

Planes, Construction of.—To readily assemble or dismantle aeroplane wings, they are composed of rib units sliding on parallel frame members. The units are spaced by ferrules sliding on the members and abutting against ferrules integral with the ribs. The members are secured to an end frame, while the rib unit at the inner end is secured by nuts, etc., and may carry integral pivot knuckles for connection to the fuselage.

122,655. Pilkington Bros., Glass Works, and L. West, Ravenhead, both in St. Helens, Lancashire. June 5, 1917.

Mirrors.—A mirror for use on aircraft, automobiles, etc., to enable objects outside the direct line of vision to be seen, is formed with two parts, one to give a bright reflection, and the other to give a subdued reflection, for use in dim and bright lights respectively. The two reflecting parts are preferably mounted back to back in a single frame adapted to be turned to bring either of the reflecting parts into use.

122,657. T. Harvey, 10, Newton Terrace, Sauchiehall Street, Glasgow, and T. G. Tulloch, Bank Buildings, St. James' Street, London. February 21, 1918.

Signalling to and from Aircraft.—For communicating to and from aircraft flying over the sea, two earth plates spaced apart are suspended in the water from the aircraft by an insulated cable or cables. The double-core cable may be replaced by two separate cables. The transmitting and receiving apparatus comprises a sending key and a make-and-break switch arranged to send impulses to the circuit connecting the earth plates.

122,686. British Emaillite Co., 30, Regent Street, Piccadilly Circus, and J. N. Goldsmith, 67, Chancery Lane, both in London. January 26, 1918.

Visibility of Aircraft, Diminishing; Lighting.—To render an aeroplane less visible, its under surface is artificially illuminated so as to approach the light intensity of the cloud background. For this purpose, the lower surface of the planes may be made translucent by using doped silk and illuminated by electric lamps placed inside the planes. Alternatively, lamps may be placed in the planes behind transparent windows in the lower surfaces or illumination by reflected light may be used. Means for cutting out some of the lamps to vary the lighting intensity are provided.

122,693. R. W. Birkett, Thicket House, Thicket Road, Sutton, Surrey. January 29, 1918.

Propeller Guards.—Comprises a counter propeller or device for aerial and marine vessels consisting chiefly of adjustable radially disposed blades adapted to be held to any desired angle in relation to the longitudinal centre line of a propeller driving-shaft. The parts of the guard usually fixed, but which may be pivoted, are carried by a ring, and have hinged to them vanes having levers which engage with loops on the toothed ring in gear with a pinion on the operating shaft.

122,705. G. F. French, Lower Moss Lane Mills, Chester Road, Manchester. February 2, 1918.

Lacing Webbing for Aircraft, etc.—A lacing webbing, chiefly adapted for use with airships, balloons, aeroplanes, etc., is formed with one or more longitudinal parts of double thickness, and the other parts of two single and separate thicknesses adapted to be opened out to form flaps for attachment purposes, the part or parts of double thickness being made of two distinct thicknesses connected together by intermediate binding warp threads. The drawings show two lengths of webbing placed side by side, and each comprising a two-ply part and parts of single thickness, the single parts being secured to a patch for attachment to a balloon or airship, so that when the two webbings are laced together by means of eyelets in the two-ply parts, a tube-like anchorage for receiving a suspension rope of the car is provided. When applied to aeroplanes, the edge of the fuselage canvas is sewn or riveted, and the eyelets are used for lacing purposes.

122,710. S. V. de Bolotoff, Kippington Court, Sevenoaks, Kent. February 5, 1918. Addition to 113,467.

Framework.—In a device for receiving strut ends in aircraft and other structures comprising two spaced angle-plates as described in the parent Specification, the angle-plates are arranged so that their sides or edges are not parallel, in order to accommodate tapered struts and longerons, and single securing pins passing through each strut-end may be used. The drawings show two plates arranged for assembling a tapering strut and a strut at an obtuse angle upon a tapered longeron. The plates are secured together by four bolts with spacing pieces arranged to prevent lateral movement of the struts. A modification is described, in which the angle edge is bent to take a double-tapered longeron. Lugs may be provided on the angle-plates to engage the sides of the struts.

122,731. S. R. Parkes, Pretoria Works, New Road, Willenhall, Staffordshire. February 28, 1918.

Wire Strainers.—Wire strainers or turn-buckles for tensioning the wires of aeroplanes comprises a U-frame, in one end of which is mounted a shackle with a hemispherical head, and in the other end of the frame is pivoted a nut through which passes an eye-bolt.

122,732. R. Field, 11, Hall Avenue, Springdale, Huddersfield, Yorkshire. March 4, 1918.

Levels and Clinometers.—A universal spirit or like level for use on aircraft, etc., of the type in which a spherical or partly spherical vessel is filled with spirit or other liquid, is provided with a bead, ball, or like float, which acts as an indicator in place of an air bubble. The flat or shallow holder has a reflecting surface so that the indicator can be seen by reflection in certain positions.

122,800. F. H. Royce and Rolls-Royce, Ltd., Nightingale Road, Osmaston Road, Derby. September 12, 1918.

Internal-Combustion Engines; Driving Gear.—Motion is transmitted from the crank-shaft to the propeller by epicyclic gearing. The internally toothed annulus is bolted to a flange on the crank-shaft. A flange secured to the driven shaft carries three planet wheels in engagement with the annulus, and a second set of wheels which engage the sun pinion. Between the casing and the pinion are interposed springs and slipping plates. The springs are located between lugs carried by the extension of the pinion, and by a member which is itself mounted in a drum-like casing. Discs faced with friction discs engage the extension by means of longitudinal serrations and alternate with similarly mounted plates on the casing. Springs press the plates together.

122,853. J. Imber, 162, Worple Road, Wimbledon, London. April 6, 1918.

Tanks.—Relates to tanks for combustible and other liquids, such as petrol tanks on aircraft, and consists in a construction specially intended to prevent leakage in the event of the tank being pierced, comprising the combination of a metal casing, a tubular or other framework fitting inside and conforming to the shape of the casing, and an outer cover of rubber or the like. The joint of the outer casing is sweated, welded, or otherwise formed without rivets. The fittings are sweated or welded to the tank and provided with at least two seatings.

H. T. P. GEE,
25, Victoria St., London, S.W.1, and 70, George St., Croydon.

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The World's Aerial Mail and Passenger Services. A general directory of the world's aerial mail, passenger and express services is given. It has been compiled from the most up-to-date information at hand, and includes particulars of proposed services as well as those already in operation. ("Aviation," January 15, 1919.)

The Siemens Type D-iv. Single-Seater Fighter. Illus. ("Flight," March 13, 1919.)

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The 270 h.p. Basse-Selve Aero Engine. Illus. ("The Engineer," March 14, 1919.)

The Liberty Aircraft Engine. Paper read at the annual meeting of the Society of Automotive Engineers. ("Automotive Industries," February 6, 1919.)

Trend of German Aeroplane Design. Summary of features of captured enemy machines issued by the Technical Department (Aircraft Production) British Ministry of Munitions. Illus. ("Automotive Industries," January 30, 1919.)

Experimental Design and Testing of Aeroplane Ribs. G. B. Fuller and Lessiter Milburn. Illus. ("Automotive Industries," February 27, 1919.)

Medical Aspects of Aviation. L. E. Stamm. ("Aëronautical Journal," January, 1919.)

REVIEW.

The Aircraft Identification Book. By R. Borlase Matthews and G. T. Clarkson. pp. 118 oct., diagrams. London, 1919: Crosby, Lockwood and Son.

A naturalist classifies animals by fundamental structural differences seldom obvious to the unprofessional eye. Superficial observers, travellers, pioneers, etc., give descriptive features such as size, colouring, stripes, possession of a trunk, tusks, horns, and so on. A llama and a camel have one hump, a dromedary two, etc. On these lines anyone who travels may, at a glance, make a fairly satisfactory descriptive classification. It requires scientific classification in the strict sense to relate the pig with the elephant, the lizard with the bird. Sometimes the descriptive classification is also a fundamental scientific classification, as the diptera among insects, four-legged, and winged insects. Mr. Borlase Matthews' classification is of the descriptive kind. As a machine is mono, bi or triplane, it has one or more engines, two or more wheels, and so on. By following Mr. Matthews' classification the inexpert, and the expert too, will speedily *place* the unknown machine in a limited class.

The idea is ingenious and useful, but scarcely merits the somewhat pompous language of the advertisement which talks of logical analysis, classified basis, analytical classification, progressive divination, accurate diagnosis, etc., almost in the same breath. Curiously enough Mr. Matthews takes for granted the simplest of all classifications that allied machines are marked with noughts, enemy machines with crosses.